THE
POPULAR SCIENCE
MONTHLY

OCTOBER, 1907

A TRIP AROUND ICELAND

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THE study of islands, whether the attention of the visitor is directed to their structure or their inhabitants, yields a peculiar pleasure. They are quite definite and unique units. They reveal interesting relations with neighboring continents, of which they so often are merely separated fragments, and they afford texts for suggestive and fascinating speculations as to past geographical conditions.

In their life no less than in their mineral features, they exhibit to the naturalist, familiar with the interpretation of forms, biological affinities with distant or near-by lands, and thereby shed side-lights, frequently instructive, upon the migrations of plants and animals. And they are, or have been, in themselves experimental stations, where the theories of specific change or specific origin may find partial endorsement or helpful refutation.

Long before Wallace wrote his "Island Life," they had attracted observers, and the unity with, or the diversity from, adjoining islands or contiguous mainlands, of their flora and fauna furnished abundant proofs of their ancient separation or their recent union with both.

An island, too, has its limits so irrevocably fixed, becomes, from its isolation, such a definite tract, that its study has the economical value of concentration and persistency. And this advantage obviously reaches phenomenal value, the more remote the island is from any other, because then its peculiarities teach the naturalist lessons in the origin of living species, or supply the geologist with new types of terrestrial architecture.

It was long ago pointed out that

> if we visit the great islands of the globe, we find that they present anomalies in their animal productions, for while some exactly resemble the nearest continents, others are widely different. Thus the quadrupeds, birds and insects of Borneo

correspond very closely to those of the Asiatic continent, while those of Madagascar are extremely unlike the African forms, although the distance from the continent is less in the latter case than in the former. And if we compare the three great islands, Sumatra, Borneo and Celebes, lying, as it were, side by side, in the same ocean—we find that the former two, although farthest apart, have almost identical productions, while the latter two, though closer together, are more unlike than Britain and Japan, situated in different oceans and separated by the largest of the great continents (Wallace).

These unexpected results warranted the inference that the contrasted areas, despite their nearness to each other, had, for long periods, been severed, and that those, on the other hand, which were widely sundered had been at some time, in some way, united by intermediate connecting land surfaces.

Iceland is an island of most respectable proportions—a little larger than Ireland; it occupies a position on the earth's surface especially interesting from its arctic relations, it furnishes sensational contrasts by reason of the union, within its limits, of the opposed empires of frost and fire; its plant life has European affinities; its insect life is restricted, but also European; its bird life has a European expression, but pertains also to the circumpolar distribution of identical birds in both hemispheres; its geological history is recent and startling, and its scenery strange and magnificent. It is, therefore, not surprising that it attracts scientific and adventuresome visitors, though it seems to the writer that these would naturally increase if, at least in America, this island received some sort of popular elucidation. Such is the purpose of this article.

Besides the especial wonders of its bold and frowning cliffs, its ice-buried mountains and its foaming and tempestuous rivers, Iceland for centuries has been the home of romance. Baring Gould was perhaps the first modern English writer who appreciated and adequately described the bewildering impressions made by Iceland upon a visitor, though he failed to see its most marvelous aspects, and he pays his tribute of praise very well indeed. It was our own Bayard Taylor who, somewhat later, on the pages of the *New York Tribune*, remarked,

not that there is no interest in Iceland itself. On the contrary, the handful of old Scandinavians there preserve for the scholars of our day a philological and historical interest, such as no equal number of men have ever achieved in the annals of the world. A thousand years ago they cut loose from Europe and carried the most virile elements of its past almost out of reach of later changes. But Iceland is so remote from us, in an intellectual as well as a material sense, that any satisfactory knowledge of it requires a special appropriation of time and study.

The easier and more common way to Iceland, the one taken by the writer, is by the United Steamship Co.'s steamers (the Danish mail line), which leave Copenhagen, at frequent intervals during the sum-

mer, stop at Leith, the port of Edinburgh, and then variously steam northward to Thorshavn on the Faroe Islands, and thence to Reykjavik, the capital of Iceland at its southwestern headland, or turn to the eastern coast of Iceland at once, and circuitously, landing at the settlements and towns in the fiord valleys, circumnavigate it, finally disembarking the traveler at Reykjavik.

It was in the latter way that the writer determined to gain some insight into the coastal features of Iceland before he made a short but instructive dash into the interior, from Reykjavik, using for that purpose the indispensable Iceland pony. This is that most conscientious, affectionate and captivating little beast, whose docility and pliability—when knowingly handled—have made him the Icelander's constant companion, his only available substitute for the trolley and the railroad.

The omniscient Cooke has not been unmindful of the prospects of profit from the chance tourist drawn to the fabled shores of Iceland, and has already provided excursion tickets from New York to Iceland with accompanying arrangements for the equipment and conduct of parties into the interior. In this way the *soi-disant* explorer may most conveniently form his plans for this unusual outing. Less dependent and more ambitious men arrange with leading guides at Reykjavik for the despatch of men and horses and provisions to the east coast from Reykjavik. They meet these expeditions at some of the settlements, and traverse the island from east to west, fording the rivers, hunting over the moors, fishing in the lakes and streams, possibly skirting the huge icefields, and reaching Reykjavik in time for the returning steamers in September. A third and most important group of visitors are professional men, who also take out considerable equipment, in which clinometers, barometers, thermometers, hammers and collecting boxes and bags replace the gun and rod.

Amongst the latter has been Professor Thorold Thoroddsen, of the University of Copenhagen, who for thirty years has made a laborious inspection of the natural features of Iceland, visiting under circumstances of danger and extreme discomfort, its most inaccessible localities, and Professor K. Keilhack, the German naturalist, whose articles both in geology and in natural history have aided greatly in the scientific interpretation of this domain of wonders, while Professor Slater, of the British Museum, has only recently contributed, in his admirable account of the birds of Iceland, the garnered results of his travel and observation to the growing library of Icelandica. In this connection I should mention the capital "Flora Icelandica," of Stefan Stefansson, which has recently appeared, and wherein the botany of Iceland receives an extended and systematic treatment.

The approach to Iceland was made in an impervious and haunting

fog which later became confounded with, and imperfectly dissipated by, torrents of rain. It was a disappointing reception, and all the more vexatious because at Faskrudsfiord, the first stopping-place, occasional raisings of the curtain gave spectral glimpses of vast snowy peaks accumulated in unseen grandeur behind the rolling folds of the mist. It was in a measure a compensation for their obscuration that plentiful showers seamed the steep cañon walls of the inlet with plunging silver cataracts. These developed with instantaneous rapidity, leaping down over the basaltic cliffs in innumerable threads.

A word descriptive of the physical configuration of Iceland will make more clear the outline and incidents of the trip about the island. Iceland has in general a subelliptical shape with its longer axis lying northeast and southwest. This approximate form is extended into a sort of lateral excrescence or finger-formed expansion at the northwest margin, in a deeply dissected peninsula, which lies between the Breitfiord and the bay of Hunafloi (see map).

The island is fringed on its eastern, northern and western shores by a continuous succession of inlets, bays, fiord-like arms, which often subdivide and branch at their heads into smaller crevices and communicate with lowlands or valleys leading back into the hills and the interior. The southern shore offers a considerable contrast to this fimbriation of its other coasts, and while it is assumed by Thoroddsen that the southern shore was at one time indented by similar inlets, to-day it presents an *entire* outline which represents broad margins of sand, flows of mud and detrital deposits, scored by glacial streams, and punctuated by lakes or lagoons, in other words, a fiorded area blocked and filled up by later blankets, and upthrown banks and plugs of sand from the sea, or by the fluviatile washings from the higher country, and the past deluges of sediments from the melting glaciers.

The trip about the island is made up of entrances into these fiords, and of skirting the coast, which presents a series of superb pictures, while the occasional stops permit transient glimpses of the life and industry of the people. Our company, on the staunch little craft *Vesta,* conducted on its devious ways by the bluff and able seaman, Captain Braun, was one of diversified elements and entertaining contrasts. A little group of French wanderers (among them, the daughter of the great student of hypnotism, Dr. Charcot, and Professor Gourdon, geologist of the French Antarctic Expedition) imparted a continental elegance to our homely equipage, the Englishmen and one most amiable and companionable Scotchman, furnished the necessary insular sobriety and steadiness, a versatile and courteous German trader aided us at all points with explanations and directions, two English ladies revealed unexpected liveliness and powers of amusing

comment, and a lovely Icelandic maiden, returning to her home, after a three years' absence in Denmark, provided a becoming touch of sweetness and roguish charm. The crew and officers were obliging and considerate, and some interesting Danes and Icelandic students completed our passenger list, which, however, expanded into unmanageable proportions, as from place to place, on our approach to Reykjavik, new applicants for berths and table-room made their appearance.

I have hinted at our unsatisfactory reception at Faskrudsfiord. In a measure this disappointment was forgotten in the sense of sudden novelty the surprising pictures before us aroused. The cloud-draped mysteries of the Faroe Islands had awakened expectations certainly, but, to the writer, at least, the scene unfolded as the steamer approached the shores of Iceland, and entered the first deep incision in its rocky sides, was of an unrecalled strangeness and incomparable with anything he had seen before.

It was at four o'clock on the afternoon of August 3 that we came in sight of Iceland after passing, many miles before, a low rocky island engulfed in the swinging curtains of the fog, and though the picture was veiled in mist it excited expectation. The island hid itself from the first vulgar stare of curiosity and drew around it its protecting veils of cloud. First indefinite outlines appeared, one range or hill behind the other, with ill-defined and evanescent openings, then steep bold profiles of dipping beds—the lava flows, apparently successive and gently elevated in mass—and then the coast came more distinctly in view with a green veil of vegetation covering but scantily the broad deep and long talus of débris and disintegrating stone, upon which long threads of falling water in silver lines were easily discerned, even to their moving particles.

On, with the palisades, perhaps 1,000 to 1,500 feet in height, revealed and then hidden in alternate intervals, in the drifting mist and hurtling rain. Finally, we turned into Faskrudsfiord, and slowly steaming up over the quiet water we saw on either side the high 'skrees' gushing with water; long sinuous lines of water, often where they fell over short escarpments forming brief waterfalls, and elsewhere broken successional cataracts, until the cliff-sides were fairly fringed and embroidered with argent lace, a really wonderful picture.

At the very head of the bay rose more lofty mountains, one behind another, in solemn vagueness, dashed with broad snow patches, intermittently seen, and always streaked with streams. These fugitive glimpses were tantalizing enough. They were also only partial. The curtains of fog, moving fretfully over the landscape, suggested, as we watched their grudging revelations, many concealed peaks.

On the north shore was a settlement of some sixty houses, with a hospital of the French government for French fishermen and sailors,

and another of the Catholic church. We had seen farther out, towards the sea, little farms with small enclosures framed in stone walls, or with turf walls, consisting of grass fields. The cemetery, near at hand, was a quaint silent bleak spot on the edge of the water, with a fence round it, and bristling with wooden crosses. Some small houses were covered with sod and had green roofs. It was all singularly new and exhilarating. The storm refused to lift nor did the rain desist. It came down in deluges, and the streams leaped more impetuously, and the cataracts became swollen and vociferous, until a murmurous roar arose from the shores around us. The fog hung low on the mountain-sides, and, as if from their drenched edges, streams poured over the sheer slopes.

Then out to sea over rolling surges and tilting swells. The palisades of rock continued, with higher peaks at intervals, and then we entered Eskifiord, where the renowned Iceland spar is obtained, those pellucid cakes of carbonate of lime, from which the optician adroitly cuts the Nicol prisms for microscopes, which again in the hands of the lithologist reveal the structure and the composition of rocks. I went ashore at night in a pelting rain, and after some miserable wandering over the shore path, by the little huts and houses, through plentiful pools of water, entered a comfortable ware room where the precious material, weighed in small cleavage rhombs, could be secured. Eighty cents was paid for one of these specimens. New quarries are reported from the south side of the island.

This beautifully clear phase of the carbonate of lime forcibly recalled analogous developments in the palisades—the trap formation—of New Jersey at home. Iceland, indeed, throughout most of its northern section is a vast basaltic terrain, a land built up of igneous effusions exuded from opening crevices in the earth's crust in viscous semi-slaggy flows, and piled upon each other, possibly beneath the surface of the sea. Elevation succeeded, and these accumulations rose gently, with only unimportant dislocations upward. They were built upon a submarine spur, probably extending interruptedly from Norway with a southern arm towards Scotland, the whole hidden chain surrounding a deep northern area which, at some time, when its now submerged barriers were exposed, may have formed a landlocked ocean, framed indeed on its southern margin by a *dry* north sea.

The igneous material involved in this construction of Iceland, though analogous to the New Jersey palisades, began its constructive work much later in geological time. The New Jersey palisades date from the Jura-triassic period, those of Iceland are referred to the middle, at the earliest, of the Tertiary age, though continuously since that time through preglacial, glacial and postglacial time, up to the present era, volcanic outbursts and new accessions, whether of lava

NORDFIORD. Skirt of fog on mountain.

or ashes, have increased its size. But, in the sequence of igneous additions, the character of the rocks has changed, and differs strikingly from the original basement basaltic flows. Thus have the fires of earth raised a monument above the tides of the Atlantic.

No sooner had this architectural wonder been raised by Pluto, than Neptune and Jupiter Pluvius conceived its destruction, and their machinations for its overthrow were inconsiderately helped by their subterranean brother. Earthquakes have doubtless altered and reduced its size, detaching or sinking broad patches or morsels of its periphery. We can imagine, to continue our simile, that Pluto, groaning and agitated over the envious assaults of the upper gods, helped to knock out some of the underpinning of his own creation.

But in their process of reduction the air deities have made Iceland most attractive, wonderfully picturesque; they have cut out its deep fiords, furrowed its cliffs, dug grottoes in its stony walls, put pinnacles and minarets along its sky-lines; they have led valleys, green with pasture and splashed with the color of flowers, down to its wave-strewn lips; they have dropped island pearls around its coasts; they have

CUPOLA-TOPPED MOUNTAIN IN SEYDISFIORD.

planted sapphire brooches upon its bosom in the great interior lakes, and spread over its shoulders the braided tresses of a hundred rivers; they have covered its mountains with diamond shields, and in their ruthless attack converted mountainous elevation into ranks of serried hills repeating the ruby pallors of the midnight sun.

Again we left Eskifiord and in our exit reviewed, as before, the steep rocky walls of the fiord, the dipping stratification, the streaming rills. Minareted summits like low parapets fenced the tops of the palisades. We passed a whale fishery with an eviscerated and skinned carcass on the dock before it, and then out over rolling waves with mist and rain, and later entered our third fiord—Nordfiord. The stormy weather was slowly succumbing to more favorable influences, and when at last the vapors rolled up into clouds we found ourselves in a deep strait between lofty walls of rock shooting out of sweeping slopes and undulating upland, which seemed in that northern sunlight, and beneath those frowning sentinels, so desolate, their austerity emphasized by a few isolated farms. One could imagine the wintry terrors of those lonely homes.

TURF-COVERED HOUSE AT SEYDISFIORD.

The streams were still running and the terraced weathering of the rocks was well shown. Towards the ocean a range of high peaks was seen, which formed the southern boundary of another fiord, twinned with the one we were in, and far back beyond the head of the fiord rose immense backs of mountains, spotted with snow. We passed again out to sea upon a rolling swell, into splendid clear water, and skirted the superb front of receding basaltic steps, each one of which was a separate flow, and where as many stages as twenty or forty were counted in their structure, showing bold stepped profiles.

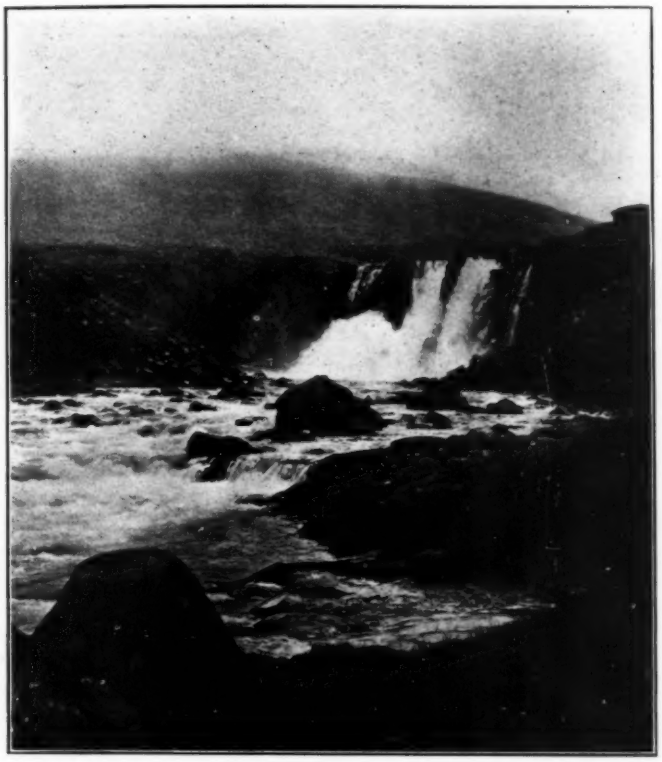
At the summits of these amazing walls, erosion and weathering seemed to have worked with greater activity, forming deep alcoves, sweeping recesses, and then cirques were seen between the lofty divisional massifs. Water-ways or shallow fiords divided this remarkable face of rock into component fractions, and as the last one appeared—sentinel to the beautiful Seydisfiord—green slopes encircled its formidable precipices holding lonely farms, and a spouting waterfall sprang outward from its riven side. We were at Seydisfiord.

The village of Seydisfiord was perhaps the first which breathed a

PONIES AT SEYDISFIORD.

very real air of comfort. It had a hospitable look. A pleasant post-office, a well-furnished apothecary shop—in which minerals and curiosities mingled with drugs and extracts—a candy store, a village hotel, and trailing groups of pretty children and young girls were not wanting to impress the senses with an unusual impression of creature and home blessings.

The important human aggregates in Iceland are along its shores. The population of the interior forms minute hamlets, or is strung out into attenuated lines of farms, many miles apart. The shore settlements meet the outside world, the wear and tear of life is greater, and exchange of material in business ways more active. Here education and culture extend themselves more quickly, and world-ideas receive acceptance and circulation. The farmers struggle with the drudgery of harvesting the hay, breeding and raising sheep and cows, making butter and repairing and making implements and houses. They become a conservative and backward element, and miss the reaction with foreign ships and visitors, and the political spirit is with them more dormant and inactive. In the shore-villages, adven-



FALLS ON THE FIORDURAU ON SEYDISFIORD.

ture, accidents, money-making and dissipation help the movement of life, the attrition is more constant between men, and they emerge more quickly from immature and limiting prepossessions. The farmer is resourceful, brave and wise in his arts, but it seems certain that information and direction would increase his earnings and widen his activity. Banks and means of loaning money have appeared in Iceland, and with them come enterprise, risks and speculation, and attendant amelioration of conditions, with new outlooks and ambitions.

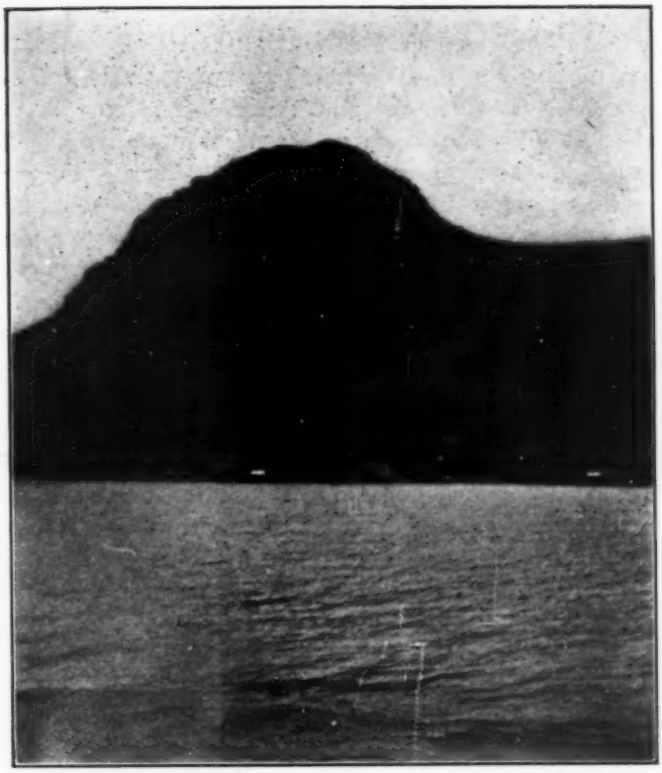
The village of Seydisfiord wanders attractively around the head of the bay, which receives the rushing waters of the Fiordurau (*the river of the fiord*), and our alert tourists assembled, early on the morning of our arrival, a group of ponies—fat and vigorous, with charming heads and exuberant manes—for an excursion up the valley of this river. The objective motive was a series of waterfalls, one behind the other, which were to be seen up the valley. These falls were the physical symptoms of the recession of the stream itself, as it wore its way backward. The rocks about them were much sculptured and worn, and offered an entertaining geological riddle as to whether the lower falls

FALLS ON THE FIORDURAU, SEYDISFIORD.

might not overtake the higher ones, or whether the series represented the scattered parts of a former fall of a height equal to the added heights of each. In the former case, the process would bring about in centuries of time a resultant lofty fall, and in the latter case their separation would probably widen as the river at the upper falls wore its way backward more and more rapidly, and left in its retreat its lagging lower companions.

Some of us rejected the assistance of the ponies, and walked. We made our way over an evil road, from which we wandered promiscuously in search of the tempting flowers, observing among them the rare *Pinguicula* which looks so like a spurred violet, and which we had taken in Newfoundland. And we ran to and fro avariciously picking up *Habenaria, Salix* (the dwarf willow), *Betula, Rumex, Plantago, Armeria, Polygonum, Gentiana, Ranunculus, Geranium, Parnassia, Potentilla, Epilobium, Papaver, Dryas, Pyrola* and many others almost forgetting the falls.

Falls (*foss*) are common objects in Iceland. They have a strong family resemblance, except the Gullfoss which is unique; but then the



VIEW GOING OUT OF SEYDISFIORD.

family has a high type of beauty. The wall character of the land, the prevalence of great snow fields, and the deluging rains furnish the two elements for first-class waterfalls, and they are excellent. As we scrambled from one to another on the Fiordurau, they improved in looks, and only the restraining finger of time prevented us from chasing the river to its last cranny of refuge. The view back over the fiord and its fringe of houses was one of great beauty.

Certainly the water present in the landscape was not confined to the river. It generously covered everything. Nothing could have been more opulent than the morasses and upland bogs we waded through, driven to the stress of a short cut by the far away summons of the steamer's whistle. Of course, we reached the steamer an hour before she stirred from the dock, with shoes that would have put a Broadway bootblack into a mania of imprecations. We left Seydisfiord regretfully, and here we bade good-bye to the courteous young Dane who will superintend the submarine cable now laid between Scotland—by way of the Shetland and Faroe islands—and Iceland.

Again out to sea, and again the panorama of sloping and beetling

palisades, of broad embrasures and galleries, dug out by weathering agencies, with the clear aqua-marine waters rolling languidly over jagged barriers of basalt. Vopnafiord seemed flat. It was our next stopping place. The French ladies declared it looked like Brittany and perhaps it did. They ought to know. It was a low shore, rocky, with green uplands and farms, and many threatening reefs. On again in fog with a coast intermittently seen to the left, and at night we passed into the arctic circle, and, as the day dawned over the magic sea, the air became brilliantly clear, the sky serene and cloudless, the waves docile and appeased.

We were far away from the shore. It was the northern edge of Nord Thingeyar Sysla with remote lines of elevation and long horizontal lines like some topographic section. We crossed the broad Axarfiord, on a sea blazing with light, and approached the islands of Minareyjar dancing in mirage, and soon passed Red Hook, carmine with iron secretions oozing from its jointed rocks, and along an old raised beach with enormous moorlands behind it, which a sporting vice-admiral of England declared were full of patridge (*ryper*), and which had a most inviting wild remote loneliness expressed in them.

(*To be continued*)

THE SACRIFICE OF THE EYES OF SCHOOL CHILDREN

THE HUMAN EYE EVOLVED FOR DISTANT VISION

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IN the evolution of the animal organism the sense of touch has served the purpose of informing the individual of objects with which it came in contact. The sense of taste likewise gave information concerning objects upon contact, but of a more specialized form. The sense of smell and that of hearing gave knowledge of objects in the vicinity and in certain instances of objects in the distance. The sense of sight seems to have been preeminently the sense by means of which the individual was enabled to adjust himself to objects at a distance. The enemy to the leeward might approach noiselessly and so could not be smelt or heard. When knowledge of the approach was revealed by the sense of touch it was too late for escape. The preservation of the individual and of the species thus depended upon the ability to see the enemy in the distance. Inasmuch as the function of the eyes has been to perceive objects at a distance rather than at close range, we are not at all surprised to find that the eyes are well adapted for distant vision, but poorly constructed for close work.

When our eyes are at perfect rest, when all the muscles which control them are relaxed, they are then adjusted for distant vision. When, on the other hand, the ciliary muscles and the muscles which move the eyeballs are at a maximum of contraction, then and then only are the eyes adjusted for close vision. Such a structure was admirably adapted to the needs of the primitive organism. The eyes were the sentinels which must always be on guard and when employed in the appropriate way there was no strain. It was of course essential that the individual should be able at times to see objects close at hand. This could be accomplished by means of contractions of delicate muscles, and as soon as the contractions were relieved the eyes were again adjusted for the more important duty of distant vision.

The strain upon the eyes is in adjusting for objects closer than at about four feet, but for all greater distances there is a minimum of strain. Hence we may speak of all objects as being *distant* which are removed as much as four feet. With this definition of the term distant it is evident that distant vision was the most common form of vision for all our ancestors, from the most primitive forms of life

to the most highly civilized races, till the last few centuries. With the invention of writing and then with the invention of the printing-press a new element was introduced, and one evidently not provided for by the process of evolution. The human eye which had been evolved for distant vision is being forced to perform a new part, one for which it had not been evolved, and for which it is poorly adapted. The difficulty is being daily augmented. The invention of printing presses has been followed by an increasing number of books, magazines and daily papers. The rural population has given place to the urban. The long days of manual labor have given way to the eight-hour system with abundant time for reading. Labor-saving devices of all sorts have added to our sedentary habits. All things seem to be conspiring to make us use our eyes more and more for the very thing for which they are the most poorly adapted. It requires no prophet to foresee that such a perversion in the use of an organ will surely result in a great sacrifice of energy, if not of health and of general efficiency.

The Amount of Light required for Reading

The eye has thus far been spoken of as though it consisted merely of delicate muscles, when in reality these are not the most significant part of it. In thinking of the eye we should never disregard the eye-muscles, but primarily the eye is a live camera consisting of a lens, dark box and sensitive plate. The retina in the back part of the eye-ball is the sensitive plate and is the most vital part of the eye. It is effected by every ray of light falling upon it. Fortunately it responds to a weak light and still is not injured by a moderately strong one. In speaking of the quantity of light it is well to have a standard. For this purpose the most convenient standard is the amount of light cast by a standard candle upon any point in the horizontal direction one foot from the candle. A light of twice this intensity is spoken of as a two-candle power, a light ten times the first is of course a ten-candle power. The light cast by a candle upon a printed page at a distance of one foot is sufficient for legibility at the normal reading distance. If the light is less than this the retina is not adequately stimulated and the reading is accomplished only after a strain more or less intense. If the light falling upon the page exceeds ten-candle power the stimulation of the retina is so great that it is displeasing to some people and is condemned by our best authorities as injurious to the retina. All are agreed that less than a single candle-power is injurious for reading, and during the present state of our knowledge it is at least safe to avoid an illumination of more than ten-candle power.

The iris may be blue, brown or gray and is that which determines the color of our eyes. It is an adjustable shutter which reflexly regulates the amount of light which enters the eye. In the presence of a

bright light the iris diaphragm contracts, reducing the size of the pupil and cutting out much of the light which would otherwise enter the eye. In the presence of a dull light the pupil enlarges, allowing a great amount of the light, such as that falling upon a book, to enter the eye and to stimulate the retina. The iris is a wonderful device, but can not in diverse illuminations perfectly equalize the amount of light entering the eye. The pupil expands inversely as the square root of the illumination. Thus if the actual illumination of the book increases ten-fold, the amount of light falling upon the retina is increased but little over three-fold. Even a twenty-five candle light sends but five-fold as much light into the eye as a single candle-power. A single candle-power seems sufficient and ten-candle power is not too much. This ability of the retina and of the iris to deal successfully with lights of such different intensities is a most useful and necessary characteristic. Unfortunately, however, the actual diversities of intensities of lights used for reading are far beyond any for which the eye can adapt itself.

Variations in the Amount of Daylight

We are in the habit of thinking of the light received from the sky—the daylight—as almost a fixed quantity during the hours from 9 in the morning till about 4 in the afternoon. The darkness preceding a storm and the occasional dark days are of course not forgotten, but, in general, daylight for the hours mentioned is thought of as at least fairly constant. To test this point observations were made at 9 A.M., 12:30 P.M., and 4:30 P.M., daily for five and one half days a week for 22 months. These tests were made in the Chicago laboratory of the American Luxfer Prism Co., and under direction of Professor Olin H. Basquin, of the Department of Physics of Northwestern University. Inasmuch as the amount of sunshine and general illumination in Chicago is almost exactly the average for the United States, these results may be regarded as typical for the whole country with the exception of such dark cities as Seattle or such light ones as Phœnix. Measurements were made of the amount of light coming through a square foot of clear glass placed horizontally in the roof of the observation building. The illuminometer was placed so far below the opening in the ceiling that the direct rays of the sun could never reach any part of the recording apparatus. The light thus measured was diffuse daylight received from the zenith of the sky. Taking the average illumination for the 22 months at 12:30 as the standard, it was found that the illumination at 9 A.M. was but 67 per cent. as great as that of mid-day. Again the illumination at 4:30 P.M. was but 27 per cent. as great as that at 12:30. Expressed in other terms, we see that the available light at 4:30 is approximately but one fourth that of noon and the light at 9 o'clock but two thirds that of noon. These

figures are the average for the school days of 22 months in one city, and although observations for a longer period and in other cities might change the results somewhat, it is safe to assume that our figures are not far from the actual conditions in a majority of our school rooms in the United States. In general a room which is barely adequately lighted at 12:30 will be 33 per cent. under-illuminated at 9 o'clock, and at 4 o'clock its illumination will be but 27 per cent. of the necessary amount.

Our difficulties are further complicated by the fact that the variations in illumination of daylight are as great between the months of the school year as between the hours of the school day. The illumination is best in the months of June, July, August and September. Then follows in order May, April, March, October, February, November, January and lastly December. Comparing the illumination of the four bright months (June, July, August and September) with the four dark months (November, December, January and February) we find that for the 22 months observed the illumination of the dark months is but 28 per cent. of that of the bright ones. This figure is found by averaging the three daily readings for each day for all the months concerned. December, the darkest month has but 18 per cent. as great illumination as June, the brightest month.

When to these variations as between months or seasons we add the variations between mid-day and morning and evening, the results are most astounding. The light at noonday in June averages almost ten-fold as much as that at 9 A.M. in December. If it is injurious to read with a light less than one or more than ten-candle power, a schoolroom that furnishes this maximum in June will be reduced to the minimum in December mornings and evenings on average days. Such deviations in the external source of light put most restricting conditions upon school architecture. How have we met the conditions and how might we construct our schoolrooms to meet the situation satisfactorily?

Rules for Lighting a Schoolroom

In our climate it is almost impossible to over-light a school room if the two following conditions are observed: (1) Never allow the direct rays of the sun to fall upon any surface within the field of vision of any pupil. (2) Avoid all glossy or shiny surfaces which reflect the light directly into the eyes of the pupils. A dead white surface is not injurious, while a darker surface may be shiny and hence injurious.

For securing adequate light the following rules are important: (1) The window space should be as much as one fifth of the total floor space, and the height of the window two thirds of the width of the room. (2) The walls, ceiling, woodwork, furniture, etc., should be a color which reflects a large amount of well-diffused light. Perhaps

the best colors for this purpose, in the order of their efficiency, are white, light yellow, light gray, light green, light blue and light pink. (3) The schoolroom should be narrow and the windows facing an unobstructed area, so that from any seat in the room a large amount of sky is visible. (4) The windows should be provided with white Holland screens, or others of a similar sort, which obstruct the direct rays of the sun, but which, when drawn down, emit into the room a maximum of diffused light. (5) There should be at hand light colored curtains which may be used to cover up all blackboards as soon as the darker parts of the room are inadequately lighted.

It is apparent to all that the construction of our school rooms has not conformed to these five simple rules. There are many rooms in which the window space is one fifth of the floor space, but certainly not a majority of all schoolrooms in America. The second rule, concerning the reflecting surfaces within the schoolroom, is broken by the extensive surfaces of black-boards and by the dingy color of the walls. Walls soon fade and become dirty and need frequent attention to keep their reflecting power approximately at its maximum. The third rule is broken by constructing rooms so large that they will accommodate fifty pupils, and by placing school buildings too close to adjoining buildings. The fourth rule is broken by the use of opaque shades which, when drawn to escape the brilliancy of the sun, leave the room darker than it would otherwise be on a dark and cloudy day. Because of this fact the schoolrooms with a southern exposure are perhaps our most poorly lighted rooms. The fifth rule, concerning the use of white screens for the black-boards, is never observed and to many may seem insignificant. The justification of the rule is found in the following facts.

Dark Corners in Schoolrooms

The ordinary school room has the light from one side. The five rows of desks are so arranged that one row is next to the windows and the last row next to the black-board on the side of the room opposite the windows. It is well known that the desks next to the black-board and farthest from the windows receive less light than the desks next the windows. That the difference between the first and fifth rows is great enough to occasion any alarm seems not to have been suspected. In the ordinary schoolroom the light reflected from the pupil's book on the first row is eight times as great as the light reflected from the book of the pupil who is so unfortunate as to sit in the row next to the black-board. The decrease of the light as the distance from the window increases is different in each room. The law of the square of the distance is not even approximately correct but it is safe to say that in the great majority of school rooms in the United States the row of desks next to the windows has many-fold more light than the rows next to the black-boards. Professor Basquin and I tested school rooms

having windows on but one side. In these rooms the variation between the first and fifth rows was from seven-fold to ten-fold. By the introduction of screens over the black-boards in the same rooms, the light at the darkest seat was increased as much as 50 per cent. That an increase of 50 per cent. in the light in the dark corners of our school rooms is important is apparent to all. Furthermore, this result can be secured with little or no cost. Most schools possess white screens, light-colored advertising maps, charts printed on white paper, etc. They may be used to cover the black-boards and when thus used they will reflect the light to the very parts of the rooms which need it most.

Because of the lack of attention which is paid to the light actually present in the schoolroom, and because of the great difficulty in adjusting our windows and shades to the varying intensities of the external source of light, it is not surprising that we should find in our schoolrooms conditions of light so bad that during many hours and days the reading of ordinary printed matter without undue strain upon the eyes is impossible.

Unwise Demands made upon the Eyes of Young Children

Until within a very few decades reading was taught by a slow and cumbrous method. The effort of reading was so great that few children enjoyed the reading of a book until after they had completed the third school year. Interesting books for children were few in number and not available for the vast majority of them. To-day this is all changed. Our methods of teaching reading are so improved that before the child has been in school a full year he begins to read books at home for his own pleasure. Our printing presses are teeming with children's books. Andrew Carnegie, or rather the movement which he so ably supports, has filled city and country with free books available for even the youngest. During the last twelve months I have tested the eyes of some 700 children. I have asked of each child an estimate of the number of books read in the preceding 12 months. One room of 31 pupils for the 12 months preceding the middle of the second school year, gave the following figures. The average number of books read by each pupil was 22. Some had read but few, while others had read many more than 22. One half of the pupils had read 20 books or more. It should be observed that this record of the number of books covers the period from the middle of the first school year to the middle of the second school year. After the second school year many pupils read regularly a book a week. In several of the grade rooms tested, the pupils of the room read on the average as many as 50 books a year. In the first three years after reaching the legal school age not a few pupils in our best city schools read 100 books. This figure is certainly far above the average, but there is a tendency

to increase the number of books read during these first three years of school. We should but deprecate the tendency and do all we can to stop it. During these three years the pupils are growing faster than during the following years. At this time there is a decrease in the nervous energy of the child. In recent studies of the order of development of motor adjustments and coordinations, it has been found that the individual first acquires control over the larger muscles and later over the finer ones. The normal activity of the child exercises mainly the larger muscles. The plays of children give the widest scope to the exercises of such muscles. The coarser movements are most predominant while the finer adjustments and the use of the smaller muscles are of secondary importance.

By our improved forms of modern education all this is changed. We put the six-year-old child to the task of reading and writing. These acts involve the use of the smaller muscles of the organism and are dependent upon more exact control of these muscles than any other act the individual is ever likely to be called upon to execute in later life. If an adult is out of practise in the use of the pen, a single hour's work is sufficient to exhaust the hand. The extreme exertion which the child puts forth to guide the pen or to follow line upon line with the eyes is so far in excess of the amount of energy required by an adult that we are not in a position to appreciate the severity of the child's task. Children upon entering school have better control of movements involving the whole arm and the wrist than of those involving the wrist and fingers. The muscular control of the eyes is adequate for all free movements of the eyes, but not sufficient to warrant the finer adjustments of continuous reading. The loss of nervous energy, necessitated by reading and writing, at the ages of from five to eight years is an unwarranted drain upon the health of the child. At this age the child needs free and vigorous movements rather than the constrained and finer ones required in reading and writing. At a later age the control over the finer muscles is adequate for the task, but in this age of rush we are crowding our little ones and inverting the order of nature. Furthermore, the tissues of the globes of the eyes are still soft and the strain of the ciliary and other eye muscles is likely to cause short-sightedness by increasing the anterior-posterior axis of the eyeballs. If the child's eyes do thus lengthen under the excessive strain, the eyes are not only weakened for vision, but they become diseased organs.

We have thus far attempted to establish the following four propositions. (1) The human eye was evolved for distant vision and the perversion incident to reading and writing would lead us to expect some great injury to the organism. (2) Although the eye may easily adjust itself to a light changing from one- to ten-candle power, the diversities of daylight during the hours of the school day and

the months of the school year are so great that the minimum and maximum extremes are frequently exceeded. (3) The necessary rules for lighting buildings are not adhered to, thus placing an unnecessary strain upon the eyes of all attempting to read and write. (4) There is a growing tendency to use the eyes at a period of life which is in every way ill fitted to the task. If these four propositions have been established, and if the pessimistic forebodings are justified, then investigations of the eyes should discover a general destruction of the eyes of civilized countries and an increasing number of eyes injured during the age of from 6 to 9.

Investigating the Eyes of School Children.

Systematic investigations of eyes upon a wide scale were not begun till 1865. At that date Dr. Herman Cohn commenced his investigations of the eyes of school children in Breslau. After having examined ten thousand children, he summarized his results as follows:

> Short-sightedness hardly exists in the village schools: the number of cases increases steadily with the increasing demands which the schools make upon the eyes, and reaches the highest point in the gymnasia.
>
> The number of short-sighted scholars rises regularly from the lowest to the highest classes in all institutions.
>
> The average degree of myopia increases from class to class, that is, the short-sighted become more so.

The circular of information of the United States Bureau of Information, No. 6, 1881, in speaking of the many investigations which had been made in this and other countries said:

> All, without a single exception, prove beyond a doubt that near-sightedness, beginning, perhaps, at nothing in the lower classes in the school and first year of school life, steadily increases from class to class in the school until in the highest grades or in the last years of school attendance it has actually developed itself in as many as 60 or 70 per cent. of all the pupils.

In all these tests children were not regarded as near-sighted unless their visual acuity in one or both eyes was but two thirds of normal vision or less. Think of the significance of these statements which are entirely authoritative. Pupils entering our schools come to us with good eyes, but if they stay with us till the end of the course, 60 to 70 per cent. of them will leave us with but two thirds normal visual acuity or less. Most of this loss of vision is caused directly by the strain put upon the eyes in reading, writing and drawing.

The Sacrifices caused by Premature Strain

The picture drawn by the investigators during the two decades following 1865 was dark indeed. The only ray of hope was found in the fact that the destruction of the eyes did not begin during the first few years of school, so that pupils dropping out before the eighth

or tenth year would probably escape with good eyes. Thus Cohn found that in the case of pupils 8½ years old there were but 5 per cent.. myopic, while of the pupils remaining the full 14 years, 63.6 per cent. were myopic. Investigations of the pupils of other cities of Germany resulted in similar findings. Investigations in America were not so numerous as those in Germany, but in general the results were the same until recent years.

Investigations carried on in Worcester, Massachusetts, in 1891, showed that in the second and third grades from 50 to 60 per cent. of the pupils possessed less than normal visual acuity. Investigations upon over 3,700 pupils of the Chicago public schools, in 1899, showed that the maximum of defective eyes was reached with pupils 9 years old. No one seems to have remarked upon this change in the grade at which the maximum destruction of the eyes is found. In fact the results seemed to have been looked upon as rather accidental and of no special significance.

Some months ago I asked myself these two questions. Is the maximum destruction of the eyes of the school children reached earlier than formerly? Secondly, if such is the case, what is the cause of it? In attempting to answer these questions I have tried to learn what recent investigators have found concerning eyes, and I have attempted personally to examine the eyes of children in schools which were significant. The data which I have secured lead me to conclude that the excessive destruction of the eyes begins several years earlier than was formerly the case in America, and earlier than is still the case in Germany and other foreign countries. As to the cause of the early injury of the eyes the results of my investigations are most significant. The highest per cent. of defective visual acuity I have thus far discovered was found in a room in which the pupils had been in school but 1½ years. This is the room referred to above in which the average number of books read by each pupil during the preceding 12 months was 22. It may not surprise you when I tell you that 84 per cent. of these little innocents had defective vision. The schoolroom in which they were seated was unusually well provided with windows and had a south exposure. Unfortunately their teacher preferred a rather dimly-lighted room and made generous use of opaque shades with which the windows were provided. The light by which the pupils read in school was in most cases certainly better than the light which they had for their reading of books at home. Some of these children in their childish ignorance took books to bed with them, and upon awakening in the morning read before breakfast. It is probable that in most cases the children at home read during the evening twilight till it was too dark to tell one word from another. Then they would retire to some dark corner of a dimly lighted room and continue the reading till supper time or bed time. Young chil-

dren have no regard for their eyes and parents are not likely to interfere with them as long as they are quiet.

My query as to the cause of the early destruction of the eyes is being answered by my investigations. It seems to be simply because our infants are reading more books than formerly, both in and out of school. In Germany the instruction during the first few years of school life is largely oral and at home the children do not read so much as our children. Furthermore, our children are to-day much better taught than three decades ago, and they read much more than formerly during the tender years of from 6 to 9.

The pessimistic forebodings expressed in the first part of this article are more than justified by the figures just presented. The eyes of our school children are being destroyed, and worse than that, the destruction is now taking place at the age of from 7 to 9 years, which makes the matter so serious that we should bestir ourselves to lessen the evil as far as possible. In the palmy days of Greece the Athenian boy was not taught to read till he was ten years old. By our modern improved form of education we injure the eyes of our children so that one half of them have defective vision before the age at which the Greek boy learned his alphabet.

The gravity of the situation is so great that I venture to offer in conclusion the following suggestions:

1. We should recognize the fact that human eyes are ill adapted for reading, writing and drawing for a long period at a time.

2. We should recognize the fact that the normal daily deviation of daylight is so great that any method of adjusting the windows shades from mere habit is inadequate.

3. In constructing school houses the window space should be as large as that described above.

4. The interior walls and ceilings should be light.

5. The amount of sky visible from each seat should be large.

6. The windows should be provided with white Holland screens or their equivalents.

7. Every schoolroom should be provided with light shades and they should be placed over the blackboards as soon as there are dark corners in the room.

8. School children's eyes should be tested annually and parents notified that an oculist should be employed in the case of all defective eyes.

9. Children should not be taught even the elements of reading or writing during the first year of school. For the ordinary reading and writing should be substituted more oral instruction in language, number work, nature study, history, singing, physical training, play and other forms of training suited to the needs of the pupil.

NOTES ON THE DEVELOPMENT OF TELEPHONE SERVICE

By FRED DELAND
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XV. Financial and Telephonic Conditions in 1884

IN 1884 the farmers in the United States harvested crops of wheat, corn and oats greater than in any previous year, while the amount of cotton raised by southern planters had been only slightly exceeded in two previous years. It should have been a good year for legitimate enterprises; but it proved an unfortunate period for many. The average export value of wheat was 20 cents a bushel less than the previous year, while the yearly range in the price of wheat in the Chicago market was 96 cents in February and 69½ cents in December. In 1883 wheat had ranged from 90 to 113; in 1882 from 91 to 140 and in 1881 from 95 to 143 cents a bushel. Thus the aggregate value of the wheat exported in 1884 was forty-six millions of dollars less than in 1882.

In January, 1884, came the suspension of the banking house of a well-known financier and also of the business of a leading broker. Following these failures a dreary dullness pervaded financial circles while a dread expectancy of further monetary troubles prevailed in all lines of industry, limiting outputs to the minimum required to meet immediate demands. Then came the eventful month of May, bringing to light the notorious wrecking of the Marine Bank, the failure of Grant & Ward, the suspension of several very prominent banking and brokerage firms and of many small ones.

As a result of the financial failures occurring on two days only, May 14 and 15, the market value of good securities depreciated over $240,000,000, a slump having a far-reaching effect many times greater than a depreciation of like amount would now have. Eleven national banks and more than a hundred private banks and banking concerns suspended payment during the year, while the total number of failures throughout the United States during 1884 was 10,968, with aggregate liabilities of $226,343,427. That is, nearly eleven thousand business houses were unable to meet monetary obligations in full, while more than ten times that number probably failed to attain to any measure of success; in other words, either went out of business for lack of funds to continue or because the future gave no promise of success. Then the net earnings of all railroads fell off about 9 per cent., while the

construction of new railroad lines practically ceased, less than one fifth the amount being expended for this purpose in 1884, that was expended in 1882. The bank clearances, which had exceeded forty billions of dollars in 1883, fell to twenty-four billions in 1884, and, as a distressing industrial depression prevailed in several foreign countries, there was only a slight export demand for our products.

Quite naturally all these grave disturbances in financial, industrial and commercial circles seriously affected the growth of the telephone industry. Thousands of subscribers were compelled to dispense with the telephone through inability to pay for its use, or by reason of the closing of places of business, while hundreds who had expected to subscribe were compelled to postpone the adoption of this serviceable utility. Nevertheless, nearly all the larger exchanges reported a moderate growth, and the net gain in subscribers reported by all the Bell companies was 11,222 for the year, making a net increase of 9 per cent., a remarkable growth considering the times and conditions. The gross earnings of all the licensee companies in 1884 exceeded $9,500,000, or 18 per cent. on a total capitalization of $53,000,000, not including the capitalization of the parent company, which was $9,602,000.

On January 1, 1884, there were 1,325 Bell exchanges in operation. During the year 1884 there were 61 new Bell exchanges opened, which, added to the 1,325 exchanges in operation, should have made a total of 1,386 when the year closed. But of 133 small exchanges, "kitten exchanges," as they were called, that had been absorbed in the consolidation of local companies, 63 were converted by the new owners into toll stations, while 70 were closed for the time being, owing to an almost total lack of support. Thus there were only 1,253 exchanges in operation on December 31, 1884, or 72 less than a year previous. Referring to these exchanges, the parent company stated in its annual report:

> As a rule, all the larger exchanges have had a steady growth, and there seems no reason to doubt that this will continue for some time to come. On the other hand, there is a pause in building exchanges in small places, and some 78 of those already started have been for the present given up, while 61 new ones have been established. The establishment of these systems in small towns was probably pushed too rapidly, in view of the stagnation of general business which followed. Many of these now abandoned will be restored upon a revival of business, and others can be put into operation under a system which is being worked out for small exchanges without a central office, and which, if as successful as we hope, will carry the telephone into a large number of towns and villages where it is now impossible to place them upon a paying basis.

In this connection it is interesting to compare the foregoing statistics with the following tabulated statement showing the average

number of subscribers connected with Bell exchanges during the past twenty-five years, and to note the steady increase in growth that is recorded during the past ten years. In 1882, the average number of subscribers connected with Bell exchanges was only 91; in 1906, it was 558, an increase of more than sixfold. This compilation is based on the statistics presented in the annual reports of the parent company, as of December 31 of each year:

Year	Exchanges	Subscribers	Average	Yearly Gain
1906	4,889	2,727,289	558	64
1905	4,532	2,241,367	494	53
1904	4,080	1,799,633	441	33
1903	3,740	1,525,167	408	29
1902	3,375	1,277,983	379	39
1901	3,005	1,020,647	340	51
1900	2,775	800,880	289	28
1899	2,426	632,946	261	43
1898	2,134	465,180	218	22
1897	1,962	384,230	196	15
1896	1,799	325,244	181	6
1895	1,613	281,695	175	6
1894	1,439	243,432	169	1
1893	1,409	237,186	168	–4
1892	1,351	232,140	172	5
1891	1,297	216,017	167	3
1890	1,241	202,931	164	13
1889	1,228	185,003	151	7
1888	1,194	171,454	144	11
1887	1,191	158,712	133	9
1886	1,180	147,068	124	7
1885	1,175	137,750	117	9
1884	1,253	134,847	108	15
1883	1,325	123,625	93	2
1882	1,070	97,728	91	

In 1884, some of the Bell licensee companies gladly furnished periodical reports to the parent company giving detailed explanations as to the method of operation and maintenance, the number of subscribers, calls per subscriber, etc. Other licensee companies objected to any and all parental supervision, and especially to furnishing the monthly reports from which data of a uniform character could be compiled. Then, as many licensees were not under the direct management of the parent company, failure to prepare and transmit the desired reports could only be deplored. Again, some of the newer companies that had been established on a speculative rather than an investment basis objected to the proposed adoption of uniform methods of operation, maintenance and construction, although the economy and advantages in standardization in methods and practise, as well as in construction and equipment, were clearly apparent to the unbiased mind. Nevertheless, the parent company did succeed in securing many statistics that are now invaluable in illustrating the progressive growth

of the telephone movement; and in its annual report for the year 1883 stated that:

With the acquirement of large interests in our licensed companies comes the necessity of more oversight of the business, and, as far as it can be obtained without absolute ownership, an exact comparison of results. The organization of the company should be shaped to meet these requirements, and with proper watchfulness and effort on our part, we may expect steady growth and improvement in the character of our business in all its branches.

The same difficulty in gathering statistics was experienced by the respective secretaries of the National Telephone Exchange Association, and by the committee allotted the work of gathering statistics. At the meeting held at the Continental Hotel, in Philadelphia, in September, 1884, Mr. W. D. Sargent, chairman of the committee on exchange statistics, presented a comprehensive report of great value, and representing an enormous amount of individual work, covering the number of exchanges, of subscribers, circuits, methods, wages, etc. Yet of the 906 exchanges belonging to members of the association, he was only able to secure reports from 210. Single exchanges formed the basis of 200 of these reports and included 30,421 subscribers, or an average of 152 subscribers to each exchange. But 79 of the 200 reported less than 50 subscribers; 49 reported between 50 and 100; 31 between 100 and 200; 14 between 200 and 300, and 10 between 300 and 400.

The editor of the *Electrical World,* in referring to the financial conditions prevailing during 1884, wrote:

Our country, equally with the other parts of the civilized world, has passed through a crisis of depression and distress. Commerce has languished, the busy hum of factories has ceased; costly machinery has rusted in idleness; banks have succumbed to the drain upon their reserves; mines have been shut down, and toilers by the hundreds of thousands have sought in vain for employment at the merest pittance. But amidst all these signs of dull times, and while suffering a natural sympathetic restriction, electrical industries of all kinds have prospered in the main and grown apace. . . . In January, when reports were current of a proposed deal between the Bell and Drawbaugh interests, the price of Bell stock was about 200. Then as the year and the hearing of evidence in behalf of Drawbaugh, in Pennsylvania, progressed, the price fell, until in May, at the time of the panic in Wall Street, it reached 150. That was the turning-point, and it rose gradually until Judge Wallace handed down his decision, when it jumped from 195 to 265.

Referring to the financial condition of the local companies at the close of 1884, the parent Bell company, in its annual report to its fourteen hundred stockholders, said:

Nearly all our licensed companies are in good condition, and many of them continue to pay regular dividends in spite of the general dullness. It has not, however, been a year when new enterprises of any kind could be easily pro-

moted, and in common with other industries, the telephone companies have found it difficult to sell stocks or bonds for their construction purposes. It has been probably as much due to this as to the lessening of the demand for telephone service that our output of instruments has decreased. Most of the companies have met this condition of things by applying their net earnings in part, and in some cases wholly, to their new construction. The result of this conservative policy, although temporarily disappointing to stockholders, has been to materially increase the intrinsic value and earning capacity of the properties, and in view of the importance of an early occupation of the field while numerous infringing claimants were striving to gain a foothold, we have no doubt the policy was the right one. How far it should be continued under the more favorable conditions that now prevail is to be carefully considered by each company.

On December 5, 1884, Judge Wallace delivered his opinion in the Drawbaugh case. In part it reads:

Concededly Bell was an original inventor of the telephone, the principle of which with the essential means for its application, are described in his first patent, and of the improved apparatus described in his second patent. . . . Mr. Cross, an expert, caused apparatus to be made in conformity to the description and to drawings as shown in Figure 7 of the patent, which proved itself to be an operative, practical telephone. Probably the date of his (Bell's) inceptive invention might be carried back to July, 1875, but irrespective of the time of the invention, the justice of his claim to be an original inventor of the telephone must remain unchallenged. It was through him also that the telephone was made known to the scientific public, and thence introduced into commercial use. . . . From 1867, to July, 1873, Drawbaugh was intimately connected with persons composing the Drawbaugh Manufacturing Company, which was engaged in manufacturing devices under Drawbaugh's patents. He was a stockholder and the master mechanic of the company. Among the officers and stockholders were many men of capital and enterprise. There came a time when the managers of the company wanted Drawbaugh to suggest new devices for the company to manufacture. He never suggested the telephone nor attempted to induce the managers of that company to investigate or exhibit his talking machine. A number of the managers and employees of this concern testify that they never heard of the existence of the talking machine during the life of the company. Without attempting to refer to other testimony to the same general effect, what has already been referred to, shows that if Drawbaugh had seriously desired to bring his talking machine into public notice and secure the fruits of his invention, he had ample opportunity to do so. . . . Without regard to other features of the case, it is sufficient to say that the defense is not established so as to remove a fair doubt of its truth, and such doubt is fatal.

LINNÉ AND THE LOVE FOR NATURE.[1]

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SPRING, always the delight of the lover and of the poet the world over, becomes more and more so the farther we go into the north. Nowhere are the spring songs so full of feeling as in Scandinavia. When the northern winter, over-dark and over-long, is past; when returning light and warmth inspire sleeping nature with new life; when the blue anemone, close to the fast-retreating snow, looks up into the cheering sun; when the birch puts on its delicate fresh green; when the thrush pours into the fragrant air its love-song, then, as Linné puts it, "love seizes even the plants," and the spirit of spring awakens the heart of man into a new joy. It was when this Swedish spring was at its best that the blomsterkung (king of flowers), Carl von Linné, was born, and in the romantic north, where fancy is still free to roam, it is natural that the good people should imagine some bond between the season and the child. And surely the May child, who in his cradle stopped crying when a flower was placed in his hand, grew up to be a lover of the flowers and of all nature.

This love for nature, which marked the whole life of Linné, was inherited; and he was brought up among the flowers in the garden of Stenbrohult, his father's Småland parsonage. The flowers were his playthings and their names almost the first words on his lips. Once when hardly four years old he followed his father to a lovely äng, or flower-covered meadow, and overheard him telling his friends the name and properties of each of the plants. After that, he never ceased to ask his father for the name of each plant he met. Once, when rebuked for forgetting and asking again in the childish way, he made up his mind to put his whole energy on keeping in memory all that he was told, for he did not wish to miss hearing about the things that were dearest to him.

Linné never forgot the race of peasants and priests from which he rose, nor did he forget the humble flowers of Stenbrohult. Years afterward when at the height of fame, he visited his early home and wrote in his notes, "To the flowers, my childhood's play-brothers of Stenbrohult on the banks of Mökeln, now I bade farewell," and then he goes on to call the plants and the weeds by name.

[1] An address delivered at Augustana College, Rock Island, Illinois, on the occasion of the celebration of the two-hundredth anniversary of the birth of Carl von Linné (Carolus Linnæus).

When the boy came to go to school he cared less for his books than for his flowers. Instead of allowing himself to be put through the educational mill of the times he preferred to roam over the fields and, when there came time for reading, to devour the books that would tell him more about his friends, the plants. He thought his teachers unfeeling and rude, and they thought him stupid. His father and mother, who wanted him to become a pastor, were discouraged and came near making him a cobbler. But the boy was not stupid, nor lazy, nor worthless. All the while, his powers of accurate observation were growing and he was storing up the knowledge that would be useful to him in the life that he was to lead. In time his powers came to be recognized and Dr. Rothman, one of his tutors at the school at Wexiö, more sympathetic than the others, assured the father that of all the scholars studying in Wexiö there was no one that gave as much hope as Carl. Thus the way was opened for him to devote himself to the study of natural science and of medicine, instead of theology, but not until after long family discussions. Once the boy heard his father say, "What one has inclination for, that will he have success in" (Det man har lust för, det har man lycka till). The boy asked him if it was really so, for if it was, he could not have success as a pastor, for which he had no inclination. The father suggested how costly his chosen scientific studies would be. The boy replied, "If the proverb has any ground, God will provide the offering. If I have success as I have inclination, so ways-out will not fail me." The father, with tearful eyes, gave his consent: "Then may God grant you success. I shall not force you into that for which you have not inclination." And so the boy set out for the University of Lund, where he won the life-long friendship of Stobæus. Here, and later at the University of Upsala, he read all the books he could find on botany and studied the plants of the gardens as well as of the fields and woods. His knowledge of plants was so unusual that Celsius, who came upon him by chance in the Botanical Garden at Upsala, took him home, and interested himself in the scientific advancement of the student. At the universities Linné put his serious energy on the sciences for which he was fitted, but never did the book learning nor the passion for acquiring knowledge cool his inborn love for the flowers.

If a childhood and youth like Linné's suggests a spring morning, so the passing from that youth into the fullness of life is like the passing into a sunshiny day, a day so beautiful that it never loses the color and the freshness of the dawn. Few lives have been more crowded than Linné's. He had time to study not only his beloved botany, but all the natural sciences, even assaying, and to earn his living as a physician. He had time to go on collecting trips throughout Sweden and parts of Europe; time to identify, name and classify

thousands of plants, insects and animals; time to write ten score scientific books and treatises; time to direct hundreds of students who gathered at Upsala from near and far to be guided by the new organizer of science; and yet in all that busy life he never was too busy to let his true feelings come out, never too busy to love the sunshine and birds and flowers. The wonderful hold he had on his students and followers shows his never-slacking enthusiasm, and even to-day this is felt by reading his travels and his scientific addresses and papers, or by following his life, so admirably recounted by Fries. He trained himself to see and note whatever was essential and to express this in as few words and as directly as possible, and yet it seems natural for him to pass from scientific description to poetic prose full of the beautiful Northern imagery, which is so rich in the Swedish language. Indeed there is so much of the imaginative in his writing that the Swedes, as Levertin has done, like to name him with their poets.

He starts on his scientific trips with a bird-like delight in the outdoors much like that of the old ballads:

> Hit befel on Whitsontide,
> Erly in a May mornyng,
> The son vp feyre can shyne,
> And the briddis mery can syng.
>
> "This is a mery mornyng," seid Litull John.
> "Be hym *th*at dyed on tre;
> A more mery man *th*en I am one
> Lyves not in Christiantë." (Robin Hood and the Monk.)

Is this very different from the spirit of Linné when he set out from Upsala to study the plants and the rocks and the people of Lapland?

> I journeyed from Upsala town the 12th of May, 1732, which was a Friday, 11 o'clock A.M., when I was 25 years old, all but twelve hours. Now began all the ground to delight and smile, now comes beautiful Flora and sleeps with Phœbus.
>
> *Omnia vere vigent et veris tempore florent*
> *Et totus fervet Veneris dulcedine mundus.*
>
> Now stood the winter rye quarter of an ell tall, and the grain had newly shown a blade. The birch began now to burst forth, and all leafy trees to show their leaves, except the elm and aspen. . . . The lark sang to us the whole way, quivering in the air.
>
> *Ecce suum tirile, tirile, suum tirile tractat.*
>
> The sky was clear and warm, the west wind cooled with a pleasant breeze, and a dark hue from the west began to cover the sky. . . . The woods began to increase more and more, the sweet lark which ere now had delighted our ears, deserted us, but yet another one meets us in the woods with as great a compliment, namely the thrush, *Turdus minor*, who, when she on the highest fir-top plays to her dearest, also lets us joy therein. Yes, she tunes in so high with her varied notes that she often overmasters the nightingale, the master of song.

As he goes on and the season advances he notes that "no place in Sweden is pleasanter to travel through in the summer" than the woods of pine, fir and "overflooding" (ofverflödig) birch. He says that although summer may be shorter here than anywhere else in the world, nowhere is it pleasanter, and he holds the midnight sun as not the least of nature's miracles. On midsummer day he gives praise for the beauty of summer and of spring, and for the air, the water, the green plants and the song of birds.

On this Lapland journey, Linné became fascinated with the little creeping pink-and-white twin-flower, calling it by his own name, and it has ever since been known as the linnæa (*Linnæa borealis* Gronovius), and even when found in the cool shades of the Adirondacks or on the pine-clad slopes of the Sierras it seems to carry with it some of the dreamy cheerfulness of the Northern midsummer.

When he gets up into the mountains, he revels in the freedom of the bracing mountain air and rejoices to find the flowers more numerous and more beautiful than he expected, and when he climbs Vallivare there is so much that is new he imagines himself in a new world. He goes through a cold driving snow-storm as he crosses over the fjäll into Norway and looks down on the landscape below:

> When we at last came down what pleasure did I not find for my tired body? I came then out from a cold and frozen fjäll down into a warm and seething valley (I sat me down to eat wild strawberries [smultron]); for snow and ice I saw green plants standing in their sweetest bloom (such high grass had I never seen in any place); for violent weather a striking scent from *Trifolio florente* [flowering clover] and other plants. . . . I was able to cool myself with cow-milk and refresh myself with food, also to sit in a chair.

Perhaps only those who have feasted on the wild strawberries (smultron) of Scandinavia can appreciate how that little naïve touch makes the whole scene full of life. From a purely scientific point of view it might have done to have told us that as he reached a certain altitude on his descent he found certain flowers in bloom and the fruit of certain plants already ripe. But personally I am glad to have my mouth, like his, water over those smultron.

And I feel sure that he had the smultron still in mind when years afterward he rejoiced at bidding a disciple God-speed on a journey to Lapland, sending with him greetings to the Lapland fjälls and flowers, and assuring him that the trip will give him memories that will be a life-long pleasure. The joy of the fjäll comes on him again in the same way as Wordsworth's heart, filled with pleasant memories of his chance walk by the shore of Ullswater, "dances with the daffodils."

Even more noteworthy than in his travels are the expressions of his sympathetic love for nature in his scientific papers and treatises. In

his "Deliciæ Naturæ" he classifies the plants by comparing their families to a great commonwealth, saying of the grass:

> The grass, in its simple drākt [costume] makes up here the peasant class; it is the most numerous and contributes the most, it takes care of itself the best, although it is daily tramped upon and vexed.

To one with such a true, sympathetic and enthusiastic love for nature, life must needs be full of meaning. There is a saying in Swedish, "Som man ropar i skogen, får man svar" (As one calls into the woods so is he answered). Linné called into the woods with a voice of love, and in like tones all nature answered. He took delight in coming upon the creeping twin-flower trailing through the pine-woods, in listening to the little chaffinch (bofink) with a great butterfly in his mouth calling home his children to dinner. He marveled at the endurance of the Lapps in going over mountains and with a human sympathy entered into their fresh, free life. He enjoyed watching the young men and women of Skåne dance about the midsumer may-pole. For him everything is worth observing and noting. With so many things to see, to think about and to love, his life is one of sunshine, and he is full of thankfulness for having been permitted to know and enjoy so much. Truly to such a human heart, as to Wordsworth,

> the meanest flower that blows can give
> Thoughts that do often lie too deep for tears.

Linné is not like the swine which "become fat on acorns, but not once look up at the tree from which the fruit fell, much less think upon him who established the tree so splendidly." He says of himself:

> I sought after God's footsteps over nature's plain and perceived in every one, even in those I could scarcely discern, an unending wisdom and power, an impenetrable completeness.

And again after declaring that God's wisdom is shown in the smallest creature as well as in the elephant and is as worthy of wonder, he repeats a favorite phrase of his:

> Great are the works of the Lord, and the one who takes heed of them he has joy therein (Store äro Herrans verk, och den som uppå dem aktar, han hafver lust deraf).

To appreciate fully Linné's love for nature we must remember that he began life early in the eighteenth century, in the very midst of the classical age of European life and letters. It was an age in which emphasis was placed upon the conventional, the formal, an age in which feeling and enthusiasm were restrained, an age of the court and the city, rather than of the country and nature. In the romantic movement, which meant a breaking away from artificial classicism, one of the most important features was the "return to nature." In the beginning of

the eighteenth century no poet thought of writing about the birds and flowers, or if he did, of using anything but stilted and conventional phrases. In such an age, long before Burns and Wordsworth, before even Rousseau, Linné leaves the conventional city for the garden, the äng, the barrskog, the fjäll; he is bold enough to neglect the conventionalized nightingale in his joy over the thrush; he ignores the conventional rules and models of writing, and in his own simple and direct way sets down truthfully the things he has seen with his own eyes and felt with his own heart; he leads the way not only for a more scientific study of nature, but also for a more poetic love for nature. With the eighteenth-century world sleeping through a musicless night, Linné's enthusiastic love for nature, so joyously and continuously expressed, must have come like the dawn song of birds calling to awake. And it is not unreasonable to suppose that through his writings and through the hundreds of students who were held at Upsala by his powerful magnetism, something of his inspiring love for nature should have been spread through Europe and all the world and have helped in leading men back to the great outdoors.

To some it may seem curious that Linné looked upon flowers and nature, at the same time from the scientific and the poetic points of view. We have, of course, plenty of amateurs who have a love for nature without a true knowledge, and we have scientists who see only the material object under their microscope and who feel or love nothing. But the examples of such scientists as Linné and Agassiz and many more show us that a scientist need not be fossilized, nor a mere instrument for dissecting, recording and classifying. A little of the poetic feeling, a little of the love and enthusiasm of Linné need not interfere with the worth of scientific work.

With the love for nature developed more, and, perhaps with the scientific attitude developed somewhat less, we have the naturalists, men like Gilbert White, Thoreau, Burroughs and Muir. These are the men who with loving and appreciative eyes observe what is near at hand. Their value lies in that they see clearly, accurately and with a true sympathy, and in that they let us share in their joy over nature. Reading their writings is like walking through the fields and woods. It opens our eyes and ears, it opens our hearts and souls, and makes us feel with David Starr Jordan: "Nowhere is the sky so blue, the grass so green, the sunshine so bright, the shade so welcome, as right here, now, to-day." Welcome indeed are the words and example of every observer who can help us see and enjoy for ourselves our own sky and grass and sunshine. Linné does this, and therefore is to be placed with the naturalists.

With the emotional, imaginative side of the love for nature still more developed, but with the same close observation and appreciation of

truth and reality, we have the poets, the nature poets of a high class, for we are not now concerned with the clever versifiers, the bookish imitators, nor with those who see nature and life morbidly or fantastically, through false and distorted glasses. The true poets, like Homer, or Shakspere, or Tennyson, see nature as truthfully as the scientists, they seize upon what is significant for their purpose, they base their imagination upon what is real and vital; they are like Wordsworth's skylark, singing up into the sky but keeping heart and eye on the nest upon the ground,

> Type of the wise, who soar, but never roam—
> True to the kindred points of Heaven and Home.

These poets are not the ones to make the nightingale and skylark sing in America, nor to be accused by Ruskin of pathetic fallacy in making their words express emotions which they know to be false. They are the ones who have a sincere insight into life and nature and express their true thought and feelings in all the imaginative beauty of their art. Linné was like a true poet in that he was capable of poetic imagination and beautiful expression, perhaps the chief difference being that with him this was incidental, with the poet supreme.

Like the scientists, Linné saw nature accurately; like the naturalists, he saw it sympathetically; like the poets, he saw it beautifully; like all of them, he saw it truthfully. Further still, like the prophets and seers, he saw the significance of things in the universe, he looked through what Carlyle calls the "show of things" into the things themselves, he penetrated into Goethe's "open secret."

The more we walk with Linné in the gardens, the ängs, the fjälls of his beloved Sweden, the more we shall appreciate how his inborn love for nature, showing itself in so many ways, was a vital part of his life, and the more we shall share in his joy in the works of creation. His love for nature leaves with us a memory, like that of a glorious morning, a sunshiny day, a calm and peaceful evening. Such a love for nature takes us out from the pent-up city and shows us, as it did Keats, how sweet it is

> to look into the fair
> And open face of heaven.

Such a love for nature fills our hearts with sunshine and joy, and, as it did for Linné, he who loved the little twin-flower, it opens our eyes to the truth and to the beauty of nature and of life.

EARLY MOVEMENTS IN THE UNITED STATES FOR A NATIONAL OBSERVATORY

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DURING the first half of the nineteenth century, the federal government was exceedingly penurious in its encouragement of knowledge and learning. Many members of congress believed that appropriations for this purpose were unconstitutional. Those members who were imbued with the theory of states-rights saw in the establishment of scientific bureaus an undue extension of the powers of the central government. Moreover, the interests of parties, classes and individuals were involved in these questions; and as a result the cause of knowledge suffered. Culture and education were less widely diffused than at the present time, and the people therefore were generally indifferent to the national encouragement of science. Even work of great practical value, such as the survey of the coast, the preparation of a nautical almanac and the study of winds and weather was regarded by many as unnecessary. The inland states were disinclined to vote money for these purposes, since it would chiefly benefit the seaboard. A few progressive men, the choice spirits of their time, however, early advocated the establishment of a national astronomical observatory.

For many years various projects for a national institution devoted to the study of astronomy were formed. Thomas Jefferson, as an amateur, made astronomical observations; and at one time had a plan for a national observatory. Some of the leading professors of Bowdoin College and citizens of Brunswick, Maine, early memorialized congress to establish an observatory in their town. Writing in 1824, H. C. Knight favored the establishment of a "National Observatory, whose top, with a sublimer intent than that of ancient Babel, should look into the sky; with complete astronomical apparatus, and resident professors, and salaries so liberal as to induce the most elevated intellects to devote their entire energies, during life, in tracing the marches and countermarches of the planets, and deciphering the golden hieroglyphics of heaven. Now Rittenhouse is above the stars, let Doctor Bowditch sit up in the top-tower, and be the first Herschel of America." When, in the thirties of the last century, the founding of a naval academy was being discussed, it was proposed to connect with it an astronomical observatory, whose professors should constitute a "board of longitude."

Many other isolated suggestions and proposals for an observatory might be mentioned.

There were four general movements for a national observatory. Each of these extended over a considerable period of time, and each was originated and chiefly promoted by a single man—by F. R. Hassler, William Lambert, John Quincy Adams and James M. Gilliss. The Hassler movement is connected with the founding of the Coast Survey, and the Lambert movement with the establishment in the United States of a first meridian. The movement of Adams formed a part of his plan for the promotion by the federal government of science, learning and public improvements. The undertakings of Gilliss on behalf of an observatory grew out of his actual experience as an astronomical observer in a little building on Capitol Hill in Washington. Each of these movements will be briefly considered.

In 1807 President Jefferson obtained a law providing for the survey of the coasts of the United States. This was the initial legislation in the establishment of the United States Coast Survey. F. R. Hassler was selected by Jefferson and his secretary of the treasury, Albert Gallatin, to undertake the preliminary work. Hassler was a Swiss refugee, and at one time was connected with a trigonometrical survey of his native land. In 1807 he was appointed a professor of mathematics at the Military Academy at West Point. He was one of the most distinguished of the early mathematicians and surveyors of the United States. Between 1807 and 1816, Hassler gave much attention to the preliminaries for the survey of the coast. He drew up a plan of operations. This provided for two astronomical observatories. They were to form the fixed points to which the survey was to be referred. They were to be used in determining time and longitude. Hassler, however, had in mind not merely the needs of the Coast Survey, but the advancement of scientific knowledge as well. The two observatories, he said, "will be permanent scientific establishments." He wished to locate one of them in Maine, and the other in lower Louisiana—that is, as far apart as possible. "Still, various considerations might occasion and favor the desire of placing one of these observatories in the city of Washington, as observatories are placed in the principal capitals of Europe, as a national object, a scientific ornament and a means of nourishing an interest for science in general." Here should be deposited the standards of weights and measures, and the chronometers and library of the Coast Survey. Hassler drew up a plan for the construction of an observatory at Washington, and he chose a location for it, "a part of the hill north of the Capitol."

From August, 1811, until October, 1815, Hassler was in England and on the continent, where he was sent to procure the necessary apparatus for the survey of the coast. The war of 1812 retarded and

interrupted his work. He succeeded, however, in obtaining a most superior collection of instruments and books. Among the instruments for the observatories were two five-foot transits of improved construction, made by Edward Troughton, of well-known contemporary fame; and two astronomical clocks, manufactured by "William Hardy from Scotland, residing in London, and who is eminent for various valuable inventions in the line of clock work and chronometer making, and for the very superior execution of all his works." Hardy had constructed similar clocks for the observatories of Greenwich and Glasgow. Hassler also purchased some books for his observatories. In 1816 his astronomical plans received the endorsement of President Madison and Secretary of the Treasury Dallas.

Under the direction of Hassler the field-work of the survey of the coast was begun in the summer of 1816, but it was suddenly brought to a close by the repeal in the spring of 1818 of a part of the act of 1807 authorizing the survey. The astronomical observatories had not yet been established. Hassler was still of the opinion that at least one of them was indispensable. When congress in 1832 revived the act of 1807, it concluded that an astronomical observatory was not necessary for the survey of the coast. The act of 1832 contained a provision that nothing in this act nor in that of 1807 "shall be construed to authorize the construction or maintenance of a permanent astronomical observatory." The establishment of an observatory had now become a favorite project of John Quincy Adams, and the democrats during his administration had especially opposed and ridiculed it. They were determined not to leave a loop-hole in the legislation for the Coast Survey, by means of which Adams might be able to gratify his long-cherished desire. The law of 1832 gave a quietus to Hassler's plan of attaching an observatory to the Coast Survey.

The second general movement for an astronomical institution under federal control was that of William Lambert, at one time a resident of Virginia and later of the District of Columbia. Lambert's movement began with his attempts to obtain legislation providing for the establishment of a prime meridian of the United States for the reckoning of longitudes. He believed that Washington in laying out the seat of government had designed that the center of the Capitol should mark the first meridian of this country. Lambert brought the subject to the attention of congress by a memorial to the house, dated City of Washington, December 15, 1809. He declared that the establishment of a first meridian was worthy of the consideration and patronage of the national legislature, since a further dependence upon Great Britain and other foreign nations would thereby be entirely removed; and he submitted a series of astronomical and mathematical papers dealing with the subject. One of these was an abstract of calculations made

by himself with a view to ascertaining the longitude of the Capitol. His figures were based upon an occultation of the star Alcyone, one of the Pleiades, by the moon, which was observed near the President's house on October 20, 1804. Lambert succeeded in deriving the capitol's approximate longitude. On March 28, 1810, a committee of the house to which Lambert's memorial had been referred recommended the passage of a law authorizing the president to cause the longitude of Washington west of Greenwich to be ascertained with the greatest possible degree of accuracy, and empowering him to procure for this purpose the necessary astronomical instruments. The movement to establish a first meridian impressed the members of congress favorably, since it seemed to involve a declaration of astronomical independence from Great Britain. A native republican meridian was to be substituted for an alien monarchical one.

On January 21, 1811, the house referred Lambert's documents to a second committee, which a month later asked to be discharged. Apparently, it felt itself unequal to the solution of the astronomical problems involved in the learned formulæ of the memorialist. For an expert opinion the house now rather oddly turned to James Monroe, Madison's secretary of state. After keeping the papers more than a year, Monroe on July 3, 1812, made a report in which he confessed his ignorance of the scientific aspects of the subject. He had no hesitation, however, in declaring that a first meridian should be established at Washington. This, he said, should be done with the greatest mathematical precision by means of a long series of observations with astronomical instruments. An "observatory would be of essential utility. It is only in such an institution, to be founded by the public, that all the necessary implements are likely to be collected together, that systematic observations can be made for any great length of time, and that the public can be made secure of the result of the labors of scientific men. In favor of such an institution it is sufficient to remark, that every nation which has established a first meridian within its own limits has established also an observatory. We know that there is one at London, at Paris, at Cadiz, and elsewhere."

Monroe's letter together with Lambert's documents were referred to a committee of the house, to which Dr. Samuel Mitchill, of New York, was chairman and John C. Calhoun a member. On January 20, 1813, this committee made a report, which was accompanied by a bill "authorizing the establishment of an Astronomical Observatory." The bill provided for the erection of an astronomical observatory on public ground within the city of Washington, and for the procuring of proper telescopes, instruments and furniture for the same. The president was to direct the construction of the building, and was to prescribe rules for the government of the new institution. He was to appoint, subject

to the confirmation of the senate, a "person of competent learning and skill, to be called the National Astronomer," who was to have charge of the observatory. The bill was never voted upon. The war with England at this time occupied the attention of congress to the exclusion of less pressing matters. Moreover, Lambert, who was diligent in promoting his project, was not in Washington for the larger part of the years 1813 and 1814.

From 1815 to 1824, Lambert pursued his hobby with the assiduity of an enthusiast. Finally his perseverance was rewarded by the passage of a joint resolution of congress on March 3, 1821, directing the president to cause the work of ascertaining the longitude of the Capitol to be undertaken. On April 10, President Monroe ordered Lambert to make the necessary "observations by lunar occultations of fixed stars, solar eclipses, or any other approved method adapted to ascertaining the longitude of the Capitol." In order to have his whole time for his new task, Lambert resigned a clerkship in the War Department. He had, however, no positive assurance that he would be paid for his astronomical work.

Lambert now established a temporary observatory. From the War Department he obtained the loan of some of the instruments which Hassler had procured in Europe for the Coast Survey. Among those that he obtained were a transit instrument, a circle of reflection, an astronomical clock and a chronometer. Rooms for their use and safekeeping were assigned in the south wing of the Capitol. To be near his work, Lambert moved to the vicinity of the Capitol. He employed William Elliot, then well known in Washington as a teacher of mathematics, as an observer. In order to make accurate transit observations, he established near the Capitol a north-and-south line, by means of concentric circles. Its direction from the transit instrument in the south wing was ascertained with great exactness. The time-pieces were carefully tested and rated.

Lambert made frequent observations during the summer of 1821. From these he deduced new values for the latitude and longitude of the Capitol. On November 8, he made an elaborate report of his work to the president. He also made two supplemental reports, one in March, 1822, and the other in December, 1823. In his report of 1821 he called the attention of the government to the need of a permanent astronomical observatory, in order to ascertain with accuracy the right ascension, declination, latitude and longitude of the moon, planets and stars, and to compute a nautical almanac. The movement of Lambert for a national observatory seems to have come to an end in 1824. The transit instrument may have been occasionally used on Capitol Hill subsequent to this time. John Quincy Adams has the following entry in his diary for November 19, 1825: "Roberdeau,

Colonel, came at eleven, I walked with him to W. Elliott's on Capitol Hill, where, with a small transit instrument, they observed the passage of the sun over the meridian. Conversation about the erection of an observatory."

The beginning of the movement of John Quincy Adams for a national observatory may be dated with the foregoing entry in his diary. The study of astronomy was for many years a favorite avocation of this illustrious statesman. He often observed and recorded the phenomena of the heavens. He read the works of Newton, Schubert, Lalande, Biot and Lacroix. A report of Adams respecting the establishment of a national observatory has been pronounced by a competent judge "well worthy the perusal of every lover of the exalted science of astronomy, both for the richness of its information and the beauty of its eloquence." In 1823 he offered to give a thousand dollars towards the establishment of an observatory at Harvard University. Writing in 1838, he said that the "observation of the sun, moon and stars has been for a great portion of my life a pleasure of gratified curiosity, of ever-returning wonder, and of reverence for the Creator and mover of these unnumbered worlds." In 1843, notwithstanding his advanced age and the poor accommodations for traveling, he accepted the invitation of the Cincinnati Astronomical Society to lay the corner-stone of their new observatory. His oration on this occasion has been called an "outline of the history of astronomy." Such was his interest in this science, and in its advancement through public means, that the founding of a national observatory became one of the cherished projects of his later life.

In his first annual message to congress, dated December 6, 1825, President Adams recommended the establishment of an astronomical observatory, either as a part of a national university or as a separate institution; and also the providing for the "support of an astronomer, to be in constant attendance of observation upon the phenomena of the heavens, and for the periodical publication of his observations." Respecting the failure of the United States to do its part in the advancing of astronomical science, Adams wrote with his accustomed candor and vigor: "It is with no feeling of pride as an American, that the remark may be made, that, on the comparatively small territorial surface of Europe, there are existing upward of one hundred and thirty of these light-houses of the skies, while throughout the American hemisphere there is not one. If we reflect for a moment upon the discoveries, which in the last four centuries have been made in the physical constitution of the universe by means of these buildings and of observers stationed in them, shall we doubt of their usefulness to every nation? And while scarcely a year passes over our heads without bringing some new astronomical discovery to light, which we must fain receive at

second-hand from Europe, are we not cutting ourselves off from the means of returning light for light, while we have neither observatory nor observer upon one half of the globe, and the earth revolves in perpetual darkness to our unsearching eyes?"

As a result of this recommendation a bill was introduced into the house, establishing an observatory in the District of Columbia and authorizing the appointment of an astronomer, two assistant astronomers and two assistants. A committee of the house made a long and favorable report on the subject. The bill was not voted upon.

Adams's recommendation for an observatory formed a part of his policy of nationalism, paternalism and internal improvements. In his first annual message he had also recommended the founding of a national university and of a naval academy, the establishment of a uniform system of weights and measures, and liberal expenditures for roads and canals. This progressive and enlightened policy did not command the support of congress, and its bold announcement early in his administration strengthened the hands of his opponents. His plan for a national observatory they represented as impracticable, and even chimerical. His rhetorical phrase, "light-houses of the skies," was circulated as an illustration of the fancies of his mind, and was used to cast reproach upon his astronomical project. Recognizing the futility of urging the construction of an observatory, Adams did not after the first year of his presidency bring it again to the attention of congress during his term in the White House. For several years he discovered no opportunity for furthering his pet measure.

In December, 1835, President Jackson announced the bequest of a considerable sum of money by James Smithson, of London, for the purpose of founding in Washington an institution "for the increase and diffusion of knowledge among men." In the house the message of the president and accompanying papers on this subject were referred to a committee of which Adams was chairman. He thus became intimately connected with the work of obtaining possession of the Smithson funds and later of deciding on their disposition and application. For more than ten years he was chairman of committees of the house on the Smithson bequest. Not until 1838, when all the requirements of the law had been complied with, did the United States obtain possession of the money. Our success in this particular was first made known in Washington in June, 1838. Adams lost no time in calling upon President Van Buren, and in explaining his views respecting the application of the income to be derived from the fund. On this subject he had probably made up his mind soon after the bequest was announced in 1835. He says that he suggested to Van Buren the "establishment of an astronomical observatory, with a salary for an astronomer and assistant, for nightly observations and periodical publications; annual

courses of lectures upon the natural, moral and political sciences. Above all no jobbing, no sinecure, no monkish stalls for lazy idlers."

Adams improved every opportunity for furthering his plan. In October, 1838, he wrote a long letter to the secretary of state ardently advocating the erection of an observatory from the Smithson fund. He estimated that for the founding of the institution two hundred and ten thousand dollars would be necessary. This he shortly raised to three hundred thousand dollars. In January, 1839, he presented his views on the subject in a resolution which he reported to the house. In 1839 he obtained from Rev. George B. Airy, the astronomer royal of Great Britain, a detailed statement respecting the expenditures of the Greenwich observatory. In each of the years 1839, 1840, 1842 and 1844, as the chairman of the committee of the house on the Smithson fund, he introduced a bill providing for an astronomical observatory. In the report which accompanied the bill of 1840, Adams, with a display of much learning, and some rhetoric, briefly recounted the history of astronomy, beginning with the first chapter of Genesis and ending with the founding of the observatory of Pulkowa near St. Petersburg in 1839.

The more ardently Adams advocated his favorite measure the less likelihood it had of meeting the approval of congress. Respecting the proper application of the income arising from the fund, the senate differed from the house. It wished to found one or more schools of learning and to encourage education, and it would not listen to Adams's proposal for a national observatory. On this latter point Adams's democratic opponents in congress were determined not to yield. The law of August 10, 1846, which provided for the application of the income of the Smithson fund, therefore, while it followed the general lines laid down by Adams, contained no provision for an astronomical observatory.

The fourth general movement for a national observatory is that with which the name of Lieutenant James M. Gilliss is connected. The scientific achievements of Gilliss are more remarkable than those of any other officer of our navy. He was wont to attribute his first impulses along scientific lines to a rather insignificant incident in his career. When he first came to Washington on duty as a midshipman, he heard the officers of the navy stigmatized as incompetent to conduct a scientific enterprise. He at once resolved to disprove the charge in his own person. In 1833 he obtained leave to prosecute a course of studies at the University of Virginia. Excessive application soon so impaired his health that he was compelled to give up his work before he had been a year in residence. In 1835 he resumed his studies at Paris and pursued them for six months.

In 1830 the Navy Department established in Washington the

Depot of Charts and Instruments. It was given charge of the unused charts and instruments of the navy. It distributed these necessary articles to the naval ships. It repaired and rated the chronometers. For the latter purpose simple meridian observations were necessary. Lieutenant Charles Wilkes, who was made superintendent of the depot in 1833, removed it to Capitol Hill. Here he erected a small observatory, 14 feet long, 13 feet wide, and 10 feet high. He installed in it one of the five-foot transit instruments, which Hassler had procured for the Coast Survey.

In 1836 Gilliss was detailed to duty at the Depot of Charts and Instruments. He shortly began to make astronomical observations in addition to those necessary for the rating of the chronometers. In the winter of 1837–8 he observed certain culminations of the moon and stars. In August, 1838, the Wilkes exploring expedition sailed from the United States on its famous voyage to the Pacific and Antarctic seas. Wilkes suggested to the secretary of the navy that in determining the longitude of the various stations of his expedition, observations made in the United States would be of the greatest value. Accordingly, Secretary of the Navy Paulding issued instructions to Gilliss to observe, during the absence of the exploring expedition, culminations of the moon and stars, eclipses of the moon, sun and Jupiter's satellites, falling stars, and any striking astronomical phenomena. He was to make also meteorological and magnetic observations.

Gilliss immediately made thorough preparations for his new work. He procured a 42-inch achromatic telescope mounted parallactically, a variation transit, an 8-inch dip circle, and a sidereal chronometer. He imported several new meteorological and magnetic instruments, to accommodate which he erected a small frame building fifty feet south of the observatory on Capitol Hill. Three or four additional passed midshipmen were attached to the depot to assist in its new work. This began in September, 1838, and did not end until June, 1842. All the astronomical observations, with the exception of those for two days in May, 1841, when Gilliss was sick, and a part of those for two other days, were made personally by Gilliss. The average time of his daily employment throughout the period was twelve hours, and he was often on his feet twenty hours out of twenty-four. The number of transits recorded exceeded ten thousand, and embraced those of the moon, planets, and about eleven hundred stars. The average number of lunar culminations observed was one hundred and ten, and of lunar occultations about twenty. The meteorological and magnetic observations were made bi-hourly day and night. All these observations were reduced by Gilliss, and were published by the government in 1845 and 1846 in two octavo volumes containing more than thirteen hundred

pages. These volumes were highly commended by the astronomers of Europe as well as those in America. They stand as a lasting monument to the great energy, indefatigable industry, scientific ardor, and consummate skill as an observer, of this young naval lieutenant.

The difficulties under which Gilliss performed his scientific work were exceedingly great. His many routine duties as superintendent of the Depot of Charts and Instruments had to be attended to daily. His transit instrument was defective. The little building used as an observatory was most inadequate. The observing slits originally extended to within three feet of the ridge-pole on each side, thus precluding all observations between 26° and 53° north declination, a region which actually includes a part of the moon's path. This defect was partly remedied by extending the aperture some five and a half degrees on the southern side, the utmost that the strength of the building permitted. One seventh of the standard stars of the Nautical Almanac still remained hidden from view. At the age of twenty-seven, Gilliss began his work without the aid or counsel of fellow scientists. Indeed, there were but few practical astronomers in the United States whom he might have consulted had he been acquainted with them. Not until 1840 did he obtain advice and assistance. He then received valuable counsel from the astronomers Richard Sheepshanks and Sears C. Walker. Gilliss says that he commenced his observations "with but little experience in the manipulation of fixed instruments; without a book relating to the subject in any manner, except Pearson's Introduction and Vince's Astronomy." He had never seen a volume of the annals of any of the European observatories.

Dr. B. A. Gould, a most competent judge, says that it was Lieutenant James M. Gilliss, "who first in all the land conducted a working observatory, he who first gave his whole time to practical astronomical work, he who first published a volume of observations, first prepared a catalogue of stars, and planned and carried into effect the construction of a working observatory as contrasted with one intended chiefly for purposes of instruction." The last clause has reference to Gilliss's work of planning and constructing the Naval Observatory. In 1841 he obtained authority to import a meridian circle for his little establishment on Capitol Hill, in Washington. Since his narrow quarters here afforded no room for the new instrument, he availed himself of the opportunity to urge the construction of a permanent observatory. Gilliss says that as the observations which he began in 1838 progressed, the "unsuitableness of the building, the defects of the transit instrument, the want of space to erect a permanent circle, and the absolute necessity of rebuilding the observatory in use, became each day more urgent." At his earnest request the commissioners of

the navy on November 30, 1841, recommended to the secretary of the navy the erection of a permanent depot for the charts and instruments belonging to the navy. They estimated the cost of site and buildings at $50,000. In his annual report to the president, dated December 4, 1841, the secretary of the navy approved the recommendation of the commissioners. From President Tyler the proposal for a new depot or observatory passed to congress, and especially to the house committee on naval affairs.

One of the principal members of this committee was Francis Mallory, a Whig representative from Virginia. On March 15, 1842, Mallory reported to the house a bill which provided for the construction of a depot of charts and instruments at a cost of $25,000. A report which accompanied the bill set forth the inadequacy of the accommodations on Capitol Hill, and the need of extending the work and usefulness of the old depot. According to Mallory the existing observatory was so frail that twice during the winter of 1841–1842 its doors had been blown off and the instruments had been left exposed to the weather. He proposed that the new depot should have increased accommodations for the study of hydrography, astronomy, magnetism and meteorology. In respect to astronomy, he said, that "not only has the navy failed to contribute to the common stock from which all our navigators borrow, but our country has never yet published an observation of a celestial body, which bore the impress 'by authority'"; and that until Gilliss began his work in 1838, no continuous astronomical observations had been made under the direction of the government.

An account of the movement in congress has been left us by Gilliss:

> Much delay occurred with the Naval Committees in congress. The Hon. Francis Mallory, to whom it was referred by the House committee, espoused the cause warmly, but the majority kept aloof from the depot (although so near) until the entire winter passed away. Finally, on the 15th March, 1842, I succeeded in persuading the only member of the committee to visit the observatory who was skeptical, and on that very day a unanimous report and bill were presented to the House of Representatives. Believing the chances of success would be greater if a bill could be passed by the Senate, by the advice of Mr. Mallory, I waited on the Naval Committee of the Senate, but my entreaties for a personal inspection of our wants were put off from time to time. The question was probably decided by an astronomical event.
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> At a meeting of the National Institute, at which the Hon. William C. Preston was present, I gave notice of having found Encke's comet with the 3½ feet achromatic, the comet being then near its perihelion. A few days subsequently I made what was intended to be a last visit to the chairman of the Senate committee, and found Mr. Preston with him. As soon as I began the conversation about the little observatory, Mr. Preston inquired whether I had not given the notice of the comet at the institute, and immediately volunteered, 'I will do all I can to help you.' Within a week a bill was passed by the Senate.

It is hardly necessary to trace its progress in the House. A majority was known to be favorable, but its number on the calendar, and the opposition of one or two members, were likely to prevent action upon it; and that it did receive the sanction of the House of Representatives at the last hour of the session of 1841–42, the navy is indebted to the untiring exertions of Dr. Mallory.

Unquestionably, Gilliss is right in giving Mallory much credit for the passage of the bill. No one, however, played a more prominent part than Gilliss himself, whether in initiating the movement for the new depot or in lining up its supporters in congress. Moreover, his signal success at the little observatory on Capitol Hill must have disposed many members to favor the measure. Other influences were working in the same direction. John Quincy Adams's agitation bore fruit for Gilliss. For several years public sentiment in behalf of a national observatory had been increasing. Observatories were being established at several of the leading schools in the United States: in 1838, at Western Reserve College, by Elias Loomis; in 1839, at Harvard College, by W. C. Bond; in 1840, at the Philadelphia High School, by Sears C. Walker and E. O. Kendall; and in 1841, at the Military Academy, by W. H. C. Bartlett.

The act of August 31, 1842, provided for the construction of a depot of charts and instruments, or the United States Naval Observatory, as the new institution came to be called. The new buildings were appropriately constructed under the direction of Gilliss. When they were completed in October, 1844, he turned them over to Lieutenant Matthew F. Maury, who was the first superintendent of the Naval Observatory. The success of Gilliss's efforts shortly brought to an end all other attempts to found a national observatory. John Quincy Adams finally accepted the Naval Observatory as a substitute for his more ambitious establishment. In April, 1846, he said that he was "delighted that an astronomical observatory—not perhaps so great as it should have been—had been smuggled into the number of the institutions of the country, under the mask of a small depot for charts."

ADDRESS OF THE PRESIDENT TO THE ENGINEERING SECTION OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE[1]

By SILVANUS P. THOMPSON, Sc.D., F.R.S.,

PAST PRESIDENT OF THE INSTITUTION OF ELECTRICAL ENGINEERS

IT would be impossible for any assembly of engineers to meet in annual gathering at the present time without some reference to the severe loss which the profession has so recently sustained by the death of Sir Benjamin Baker. Born in 1840, he had attained while still a comparatively young man to a position in the front rank of constructive engineers. His contributions to science cover a considerable range, but were chiefly concerned with the strength of materials, into which he made valuable investigations, and with engineering structures generally. His name will doubtless be chiefly associated with the building of great bridges, to the theory of which he contributed an important memoir entitled "A Theoretical Investigation into the Most Advantageous System of Constructing Bridges of Great Span." In this work he set forth the theory of the cantilever bridge. Upon the plan there laid down he built the Forth Bridge, besides many other large bridges in various parts of the world. With that memorable structure, completed in 1890, his name will ever be associated; but he will be remembered henceforth also as the engineer who was responsible for the great dam across the Nile at Assouan, a work which promises to have an influence for all time upon the fortunes of Egypt and upon the prosperity of its population. Sir Benjamin Baker was, moreover, closely associated with the internal railways of London, both in the early days of the Metropolitan Railway and in the later developments of the deep-level tubes. He was elected a fellow of the Royal Society in 1890, became president of the Institution of Civil Engineers in 1895, and was a member of council of the Institution of Mechanical Engineers, besides being an active member of the Royal Institution and of the British Association. He was also a member of the council of the Royal Society at the time of his death.

He enjoyed many honorary distinctions, including degrees conferred by the Universities of Cambridge and Edinburgh. In 1890 there was conferred upon him the title of K.C.M.G., and in 1902 that of K.C.B.

[1] Leicester, 1907. The address concluded with a section on the education of engineers.

He had but just returned from Egypt, whither he had gone in connection with the project for raising the height of the Assouan dam, so as to increase its storage to more than double the present volume, when he died very suddenly on May 19, in his sixty-seventh year.

The Development of Engineering and its Foundation on Science

We live in an age when the development of the material resources of civilization is progressing in a ratio without parallel. International commerce spreads apace. Ocean transport is demanding greater facilities. Steamships of vaster size and swifter speed than any heretofore in use are being built every year. Not only are railways extending in all outlying parts of the world, but at home, where the territory is already everywhere intersected with lines, larger and heavier locomotives are being used, and longer runs without stopping are being made by our express trains. The horsed cars on our tramways are now being mostly superseded by larger cars, electrically propelled and traveling with greatly increased speeds. For the handling of the ever-increasing passenger traffic in our great cities electric propulsion has shown itself a necessity of the time; witness the electric railways in Liverpool and the network of electrically worked tube railways throughout London. In ten years the manufacture of automobile carriages of all sorts has sprung up into a great industry. Every year sees a greater demand for the raw materials and products, out of which the manufacturer will in turn produce the articles demanded by our complex modern life. We live and work in larger buildings; we make more use of mechanical appliances; we travel more, and our traveling is more expeditious than formerly; and not we alone but all the progressive nations. The world uses more steel, more copper, more aluminium, more paper; therefore requires more coal, more petroleum, more timber, more ores, more machinery for the getting and working of them, more trains and steamships for their transport. It requires machines that will work faster or more cheaply than the old ones to meet the increasing demands of manufacture; new fabrics; new dyes; even new foods; new and more powerful means of illumination; new methods of speaking to the ends of the earth.

We must not delude ourselves with imagining that the happiness and welfare of mankind depend only on its material advancement; or that moral, intellectual and spiritual forces are not in the ultimate resort of greater moment. But if the inquiry be propounded what it is that has made possible this amazing material progress, there is but one answer that can be given—science. Chemistry, physics, mechanics, mathematics, it is these that have given to man the possibility of organizing this tremendous development. And the great profession

which has been most potent in applying these branches of science to wield the energies of nature and direct them to the service of man has been that of the engineer. Without the engineer how little of all this activity could there have been; and without mathematics, mechanics, physics and chemistry, where were the engineer?

If looking over this England of Edward the Seventh we try to put ourselves back into the England of Edward the Sixth—or for that matter of any pre-Victorian monarch—we must admit that the differences to be found in the social and industrial conditions around us are due not in any appreciable degree to any changes in politics, philosophy, religion, or law, but to science and its applications. If we look abroad, and contrast the Germany of Wilhelm the Second with the Germany of Charles the Fifth, we shall come to the like conclusion. So also in Italy, in Switzerland, in every one indeed of the progressive nations. And it is precisely in the stagnant nations, such as Spain, or Servia, where the cultivation of science has scarcely begun, that the social conditions remain in the backward state of the middle ages.

Interaction of Abstract Science and its Applications

In engineering, above all other branches of human effort, we are able to trace the close interaction between abstract science and its practical applications. Often as the connection between pure science and its applications has been emphasized in addresses upon engineering, the emphasis has almost always been laid upon the influence of the abstract upon the concrete. We are all familiar with the doctrine that the progress of science ought to be an end in itself, that scientific research ought to be pursued without regard to its immediate applications, that the importance of a discovery must not be measured by its apparent utility at the moment. We are assured that research in pure science is bound to work itself out in due time into technical applications of utility, and that the pioneer ought not to pause in his quest to work out potential industrial developments. We are invited to consider the example of the immortal Faraday, who deliberately abstained from busying himself with marketable inventions arising out of his discoveries, excusing himself on the ground that he had no time to spare for money-making. It is equally true, and equally to the point, that Faraday, when he had established a new fact or a new physical relation, ceased from busying himself with it and pronounced that it was now ready to be handed over to the mathematicians. But, admitting all these commonplaces as to the value of abstract science in itself and for its own sake, admitting also the proposition that sooner or later the practical applications are bound to follow on upon the discovery, it yet remains true that in this thing the temperament of the discoverer

counts for something. There are scientific investigators who can not pursue their work if troubled by the question of ulterior applications; there are others no less truly scientific who simply can not work without the definiteness of aim that is given by a practical problem awaiting solution. There are Willanses as well as Regnaults; there are Whitworths as well as Poissons. The world needs both types of investigator; and it needs, too, yet another type of pioneer, namely, the man who, making no claim to original discovery, by patient application and intelligent skill turns to industrial fruitfulness the results already attained in abstract discovery.

There is, however, another aspect of the relation between pure and applied science, the significance of which has not been hitherto so much emphasized, but yet is none the less real—the reaction upon science and upon scientific discovery of the industrial applications. For while pure science breeds useful inventions, it is none the less true that the industrial development of useful inventions fosters the progress of pure science. No one who is conversant with the history, for example, of optics can doubt that the invention of the telescope and the desire to perfect it were the principal factors in the outburst of optical science which we associate with the names of Newton, Huygens and Euler. The practical application, which we know was in the minds of each of these men, must surely have been the impelling motive that caused them to concentrate on abstract optics their great and exceptional powers of thought. It was in the quest—the hopeless quest—of the philosophers' stone and the elixir of life that the foundations of the science of chemistry were laid. The invention of the art of photography has given immense assistance to sciences as widely apart as meteorology, ethnology, astronomy, zoology and spectroscopy. Of the laws of heat men were profoundly ignorant until the invention of the steam engine compelled scientific investigation; and the new science of thermodynamics was born. Had there been no industrial development of the steam engine, is it at all likely that the world would ever have been enriched with the scientific researches of Rankine, Joule, Regnault, Hirn or James Thomson? The magnet had been known for centuries, yet the study of it was utterly neglected until the application of it in the mariners' compass gave the incentive for research.

The history of electric telegraphy furnishes a very striking example of this reflex influence of industrial applications. The discovery of the electric current by Volta and the investigation of its properties appear to have been stimulated by the medical properties attributed in the preceding fifty years to electric discharges. But, once the current had been discovered, a new incentive arose in the dim possibility it suggested of transmitting signals to a distance. This was certainly a possibility, even when only the chemical effects of the current had yet been found out.

Not, however, until the magnetic effects of the current had been discovered and investigated did telegraphy assume commercial shape at the hands of Cooke and Wheatstone in England and of Morse and Vail in America. Let us admit freely that these men were inventors rather than discoverers: exploiters of research rather than pioneers. They built upon the foundations laid by Volta, Oersted, Sturgeon, Henry and a host of less famous workers. But no sooner had the telegraph become of industrial importance, with telegraph lines erected on land and submarine cables laid in the sea, than fresh investigations were found necessary; new and delicate instruments must be devised; means of accurate measurement heretofore undreamed of must be found; standards for the comparison of electrical quantities must be created; and the laws governing the operations of electrical systems and apparatus must be investigated and formulated in appropriate mathematical expressions. And so, perforce, as the inevitable consequence of the growth of the telegraph industry, and mainly at the hands of those interested in submarine telegraphy, there came about the system of electrical and electromagnetic units, based on the early magnetic work of Gauss and Weber, developed further by Lord Kelvin, by Bright and Clark, and last but not least by Clerk Maxwell. Had there been no telegraph industry to force electrical measurement and electrical theory to the front, where would Clerk Maxwell's work have been? He would probably have given his unique powers to the study of optics or geometry; his electromagnetic theory of light would never have leaped into his brain; he would never have propounded the existence of electric waves in the ether. And then we should never have had the far-reaching investigations of Heinrich Hertz; nor would the British Association at Oxford in 1894 have witnessed the demonstration of wireless telegraphy by Sir Oliver Lodge. A remark of Lord Rayleigh's may here be recalled, that the invention of the telephone had probably done more than anything else to make electricians understand the principle of self-induction.

In considering this reflex influence of the industrial applications upon the progress of pure science it is of some significance to note that for the most part this influence is entirely helpful. There may be sporadic cases where industrial conditions tend temporarily to check progress by imposing persistence of a particular type of machine or appliance; but the general trend is always to help to new developments. The reaction aids the action; the law that is true enough in inorganic conservative systems, that reaction opposes the action, ceases here to be applicable, as indeed it ceases to be applicable in a vast number of organic phenomena. It is the very instability thereby introduced which is the essential of progress. The growing organism acts on its environment, and the change in the environment reacts on the

organism—not in such a way as to oppose the growth, but so as to promote it. So is it with the development of pure science and its practical applications.

In further illustration of this principle one might refer to the immense effect which the engineering use of steel has had upon the study of the chemistry of the alloys. And the study of the alloys has in turn led to the recent development of metallography. It would even seem that through the study of the intimate structure of metals, prompted by the needs of engineers, we are within measurable distance of arriving at a knowledge of the secret of crystallogenesis. Everything points to the probability of a very great and rapid advance in that fascinating branch of pure science at no distant date.

History of the Development of Electric Motive Power

There is, however, one last example of the interaction of science and industry which may claim closer attention. In the history of the development of the electric motor one finds abundant illustration of both aspects of that interaction.

We go back to the year 1821, when Faraday, after studying the phenomena of electromagnetic deflexion of a needle by an electric current (Oersted's discovery), first succeeded in producing continuous rotations by electromagnetic means. In his simple apparatus a piece of suspended copper wire, carrying a current from a small battery, and dipping at its lower end into a cup of mercury, rotated continuously around the pole of a short bar-magnet of steel placed upright in the cup. In another variety of this experiment the magnet rotated around the central wire, which was fixed. These pieces of apparatus were the merest toys, incapable of doing any useful work; nevertheless they demonstrated the essential principle, and suggested further possibilities. Two years later, Barlow, using a star-wheel of copper, pivoted so that the lowest point of the star should make contact with a small pool of mercury, found that the star-wheel rotated if a current was sent through the arm of the star while the arm itself was situated between the poles of a steel horseshoe-magnet. Shortly afterwards Sturgeon improved the apparatus by substituting a copper disc for the star-wheel. The action was the same. A conductor, carrying an electric current, if placed in a magnetic field, is found to experience a mechanical drag, which is neither an attraction nor a repulsion, but a lateral force tending to move it at right angles to the direction of flow of the current and at right angles to the direction of the lines of the magnetic field in which it is situated. Still this was a toy. Two years later came the announcement by Sturgeon of the invention of the soft-iron electromagnet, one of the most momentous of all inventions, since upon it practically the whole of the constructive part of electrical

engineering is based. For the first time mankind was furnished with a magnet the attractive power of which could be increased absolutely indefinitely by the mere expenditure of sufficient capital upon the iron core and its surrounding copper coils, and the provision of a sufficiently powerful source of electric current to excite the magnetization. Furthermore, the magnet was under control, and could be made to attract or to cease to attract at will by merely switching the current on or off; and, lastly, this could be accomplished from a distance, even from great distances away. How slowly the importance of this discovery was recognized is now a matter for astonishment. To state that Sturgeon died in poverty twenty-six years later is sufficient to indicate his place among the unrequited pioneers of whom the world is not worthy. Six years elapsed, and then there came a flood of suggestions of electric motors in which was applied the principle of intermittent attraction by an electromagnet. Henry in 1831 and Dal Negro in 1832 produced see-saw mechanisms so operated. Ritchie in 1833 and Jacobi in 1834 devised rotatory motors. Ritchie pivoted a rapidly commutated electromagnet between the poles of a permanent magnet—a true type of the modern motor—while Jacobi caused two multipolar electromagnets, one fixed, one movable, to put a shaft into rotation and propel a boat. A perplexing diminution of the current of the battery whenever the motor was running caused Jacobi to investigate mathematically the theory of its action. In a masterly memoir he laid down a few years later the theory of electric motive power. But in the intervening period, in 1831, Faraday had made the cardinal discovery of the mechanical generation of electric currents by magneto-electric induction, the fundamental principle of the dynamo. Down to that date the only known way—save for the feeble currents of thermopiles—to generate electric currents had been the pile of Volta, or one of the forms of battery which had been evolved from it. Now, by Faraday's discovery, the world had become possessed of a new source. And yet again, strange as it may seem, years elapsed before the world—that is, the world of engineers—discovered that an important discovery had been made. Not till some thirty years later were any magneto-electric machines made of a sufficient size to be of practical service even in telegraphy, and none were built of a sufficient power to furnish a single electric light until about the year 1857. In the meantime in America other electric motors, to be driven by batteries, had been devised by Davonport and by Page; the latter's machine had an iron plunger to be sucked by electromagnetic attraction into a hollow coil of copper wire, thereby driving a shaft and flywheel through the intermediate action of a connecting-rod and crank. Page's was, in fact, an electric engine, with two-foot stroke, single-acting, of between three and four horse-power. The battery occupied about three

cubic feet and consumed, according to Page, three pounds of zinc per horse-power per day. This must have been an under-estimate; for if Daniell's cells were used the minimum consumption for a motor of 100 per cent. efficiency is known to be about two pounds of zinc per horse-power per hour.

Electric Motive Power Impossible in 1857

Upon the state of development of electric motors fifty years ago information may be gleaned from an exceedingly interesting debate at the Institution of Civil Engineers upon a paper read April 21, 1857, "On Electromagnetism as a Motive Power," by Mr. Robert Hunt, F.R.S. In this paper the author states that, though long-enduring thought has been brought to bear upon the subject, and large sums of money have been expended on the construction of machines, "yet there does not appear to be any nearer approach to a satisfactory result than there was thirty years ago." After explaining the elementary principles of electromagnetism, he describes the early motors of Dal Negro, Jacobi, Davenport, Davidson, Page and others. Reviewing these and their non-success as commercial machines, he says: "Notwithstanding these numerous trials . . . it does not appear that any satisfactory explanation has ever been given of the causes which have led to the abandonment of the idea of employing electricity as a motive power. It is mainly with the view of directing attention to these causes that the present communication has been written." He admits that electromagnets may be constructed to give any desired lifting power; but he finds that the attractive force on the iron keeper of a magnet of his own, which held 220 pounds when in contact, fell to thirty-six pounds when the distance apart was only one-fiftieth of an inch. To this rapid falling off of force, and to the hardening action on the iron of the repeated vibrations due to the mechanical concussion of the keeper, he attributed the small power of the apparatus. Also he remarked upon the diminution of the current which is observed to flow from the battery when the motor was running (which Jacobi had, in his memoir on the theory, traced to a counter electromotive force generated in the motor itself), and which reduced the effort exerted by the electromagnets; this diminution he regarded as impairing the efficiency of the machine. "All electromagnetic arrangements," he says, "suffer from the cause named, a reduction of the mechanical value of the prime mover, in a manner which has no resemblance to any of the effects due to heat regarded as a motive power." Proceeding to discuss the batteries he remarked that as animal power depends on food, and steam power on coal, so electric power depends on the amount of zinc consumed; in support of which proposition he cited the experiments of Joule. He gives as his own results

that for every grain of zinc consumed in the battery his motor performed a duty equivalent to lifting eighty-six pounds one foot high. Joule and Scoresby, using Daniell's cells, had found the duty to be equivalent to raising eighty pounds one foot high, being about half the theoretical maximum duty for one grain of zinc. In the Cornish engine, doing its best duty, one grain of coal was equivalent to a duty of raising one hundred and forty-three pounds one foot high. He put the price of zinc at £35 per ton as compared with coal at less than £1 per ton, which makes the cost of power produced by an electrc motor —if computed by the consumption of zinc in a battery—about sixty times as great as that of an equal power produced by a steam-engine consuming coal. He concludees that "it would be far more economical to burn zinc under a boiler and to use it for generating steam power than to consume zinc in a battery for generating electromagnetical power."

In the discussion which followed, several men of distinction took part. Professor William Thomson, of Glasgow (Lord Kelvin), wrote, referring to the results of Joule and Scoresby: "These facts were of the highest importance in estimating the applicability of electromagnetism, as a motive power, in practise; and, indeed, the researches alluded to rendered the theory of the duty of electromagnetic engines as complete as that of the duty of waterwheels was generally admitted to be. Among other conclusions which might be drawn from these experiments was this: that, until some mode of producing electricity as many times cheaper than that of an ordinary galvanic battery as coal was cheaper than zinc, electromagnetic engines could not supersede the steam-engine." Mr. W. R. Grove (Lord Justice Sir William Grove) remarked that a practical application of the science appeared to be still distant. The great desideratum, in his opinion, was not so much improvement in the machine as in the prime mover, the battery, which was the source of power. At present the only available use for this power must be confined to special purposes where the danger of steam and the creation of vapor were sought to be avoided, or where economy of space was a great consideration. Professor Tyndall agreed with the last speaker, but suggested that there might be some way of mitigating the apparent diminution of power due to the induction of opposing electromotive forces in the machine itself. Mr. C. Cowper spoke of some experiments, made by himself and Mr. E. A. Cowper, showing the advantage gained by properly laminating the iron cores used in the motor. He put the cost of electric power at £4 per horsepower per hour. He deprecated building electric motors with reciprocating movements and cranks; described the use of silver commutators; and mentioned the need of adjusting the lead given to the contacts. There was, he said, no reason to suppose that electric motors could be

made as light as steam-engines. Even in the case of small motors of one tenth or one hundredth of a horse-power, for light work, where the cost of power was of small consequence, a boy or a man turning a winch would probably furnish power at a cheaper rate. Mr. Alfred Smee agreed that the cost would be enormous for heavy work. Although motive power could not at present be produced at the same expense on a large scale by the battery as by coal, still they were enabled readily to apply the power at any distance from its source; the telegraph might be regarded as an application of motive power transmitted by electricity. Mr. G. P. Bidder considered that there had been a lamentable waste of ingenuity in attempting to bring electromagnetism into use on a large scale. Mr. Joule wrote to say that it was to be regretted that in France the delusion as to the possibility of electromagnetic engines superseding steam still prevailed. He pointed out, as a result of his calorimeter experiments, that if it were possible so to make the electric engine work as to reduce the amount to a small fraction of the strength which it had when the engine was standing still, nearly the whole of the heat (energy) due to the chemical action of the battery might be evolved as work. The less the heat evolved, as heat, in the battery, the more perfect the economy of the engine. It was the lower intensity of chemical action of zinc as compared with carbon, and the relative cost of zinc and coal, which decided so completely in favor of the steam-engine. Mr. Hunt, replying to the speakers in the discussion, said that his endeavor had been to show that the impossibility of employing electromagnetism as a motive power lay with the present voltaic battery. Before a steam-engine could be considered, the boiler and furnace must be considered. So likewise must the battery if electric power were to become economical. Then the president, Mr. Robert Stephenson wound up the discussion by remarking that there could be no doubt that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question, commercially speaking. The mechanical application seemed to involve almost insuperable difficulties. The force exhibited by electromagnetism, though very great, extended through so small a space as to be practically useless. A powerful magnet might be compared to a steam-engine with an enormous piston, but with exceedingly short stroke; an arrangement well known to be very undesirable.

In short, the most eminent engineers in 1857 one and all condemned the idea of electric motive power as unpractical and commercially impossible. Even Faraday, in his lecture on "Mental Education" in 1854, had set down the magneto-electric engine along with mesmerism, homeopathy, odylism, the caloric engine, the electric light, the sympathetic compass, and perpetual motion as coming in different degrees

amongst "subjects uniting more or less of the most sure and valuable investigations of science with the most imaginary and unprofitable speculation, that are continually passing through their various phases of intellectual, experimental or commercial development, some to be established, some to disappear, and some to recur again and again, like ill weeds that can not be extirpated, yet can be cultivated to no result as wholesome food for the mind."

Fifty Years Later

Fifty years have fled, and Hunt, Grove, Smee, Tyndall, Cowper, Joule, Bidder and Stephenson have long passed away. Lord Kelvin remains the sole and honored survivor of that remarkable symposium. But the electric motor is a gigantic practical success, and the electric motor industry has become a very large one, employing thousands of hands. Hundreds of factories have discarded their steam-engines to adopt electric-motor driving. All traveling cranes, nearly all tram-cars, are driven by electric motors. In the navy and in much of the merchant service the donkey-engines have been replaced by electric motors. Electric motors of all sizes and outputs, from one twentieth of a horse-power to 8,000 horse-power, are in commercial use. One may well ask: What has wrought this astonishing revolution in the face of the unanimous verdict of the engineers of 1857?

The answer may be given in terms of the action and reaction of pure and applied science. Pure science furnished a discovery; industrial applications forced its development; that development demanded further abstract investigation, which in turn brought about new applications. It was beyond all question the development of the dynamo for the purposes of electrotyping and electric light which brought about the commercial advent of the electric motor. For about that very time Holmes and Siemens and Wilde and Wheatstone were at work developing Faraday's magneto-electric apparatus into an apparatus of more practical shape; and the electric lighthouse lamp was becoming a reality which Faraday lived to see before his death in 1867. That eventful year witnessed the introduction of the more powerful type of generator which excited its own magnets. And even before that date a young Italian had made a pronouncement which, though it was lost sight of for a time, was none the less of importance. Antonio Pacinotti in 1864 described a machine of his own devising, having a specially wound revolving ring-magnet placed between the poles of a stationary magnet, which, while it would serve as an admirable generator of electric currents if mechanically driven, would also serve as an excellent electric motor if supplied with electric currents from a battery. He thereupon laid down the principle of reversibility of action, a principle more or less dimly foreseen by others, but never before so

clearly enunciated as by him. And so it turned out in the years from 1860 to 1880, when the commercial dynamo was being perfected by Gramme, Wilde, Siemens, Crompton and others, that the machines designed specially to be good and economical generators of currents proved themselves to be far better and more efficient motors than any of the earlier machines which had been devised specially to work as electro-magnetic engines. Moreover, with the perfection of the dynamo came that cheap source of electric currents which was destined to supersede the battery. That a dynamo driven by a steam-engine furnishing currents on a large scale should be a more economical source of current than a battery in which zinc was consumed, does not appear to have ever occurred to the engineers who, in 1857, discussed the feasibility of electric motive power. Indeed, had any of them thought of it, they would have condemned the suggestion as chimerical. There was a notion abroad—and it persisted into the eighties—that no electric motor could possibly have an efficiency higher than 50 per cent. This notion, based on an erroneous understanding of the theoretical investigations of Jacobi, certainly delayed the progress of events. Yet the clearest heads of the time understood the matter more truly. The true law of efficiency was succinctly stated by Lord Kelvin in 1851, and was recognized by Joule in a paper written about the same date. In 1877 Mascart pointed out how the efficiency of a given magneto-electric machine rises with its speed up to a limiting value. In 1879 Lord Kelvin and Sir William Siemens gave evidence before a parliamentary committee as to the possible high efficiency of an electric transmission of power; and in August of the same year, at the British Association meeting at Sheffield, the essential theory of the efficiency of electric motors was well and admirably put in a lecture by Professor Ayrton. In 1882 the present author designed, in illustration of the theory, a graphic construction, which has been ever since in general use to make the principle plain. The counter-electromotive force generated by the motor when running, which Hunt and Tyndall deplored as a defect, is the very thing which enables the motor to appropriate and convert the energy of the battery. Its amount relatively to the battery's own electromotive force is the measure of the degree to which the energy which would otherwise be wasted as heat is utilized as power. Pure science stepped in, then, to confirm the possibility of a high efficiency in the electric motor *per se*. But pure science was also brought into service in another way. An old and erroneous notion, which even now is not quite dead, was abroad to the effect that the best way of arranging a battery was so to group its component cells that its internal resistance should be equal to the resistance of the rest of the circuit. If this were true, then no battery could ever have an efficiency of more than 50 per cent. It was supposed in many quarters that

this misleading rule was applicable also to the dynamo. The dynamo makers discovered for themselves the fallacy of this idea, and strove to reduce the internal resistance of the armatures of their machines to a minimum. Then the genius of the lamented John Hopkinson led him to apply to the design of the magnetic structure of the dynamo abstract principles upon which a rational proportioning of the iron and copper could result. A similar investigation was independently made by Gisbert Kapp, and between these accomplished engineers the foundations of dynamo design were set upon a scientific basis. To the perfection of the design the magnetic studies of our ex-president, Professor Ewing, contributed a notable part, since they furnished a basis for calculating out the inevitable losses of energy in armature cores by hysteresis and parasitic currents in the iron when subjected to recurring cycles of magnetization. Able constructive engineers, Brown Mordey, Crompton and Kapp, perfected the structural development, and the dynamo within four or five years became, within its class, a far more highly efficient machine than any steam-engine. And as by the principle of reversibility every dynamo is also capable of acting as a motor, the perfection of the dynamo implied the perfection, both scientific and commercial, of the motor also. The solution in the eighties of the problem how to make a dynamo to deliver current at a constant voltage when driven at a constant speed, found its counterpart in the solution by Ayrton and Perry of the corresponding problem how to make a motor which would run at constant speed when supplied with current at a constant voltage. Both solutions depend upon the adoption of a suitable compound winding of the field magnets.

A little later alternating currents claimed the attention of engineers; and the alternating current generator, or "alternator," was developed to a high degree of perfection. To perfect a motor for alternating currents was not so simple a matter. But again pure science stepped in, in the suggestion by Galileo Ferraris of the extremely beautiful theorem of the rotatory magnetic field, due to the combination of two alternating magnetic fields equal in amplitude, identical in frequency and in quadrature in space, but differing from each other by a quarter-period in phase. To develop on this principle a commercial motor required the ingenuity of Tesla and the engineering skill of Dobrowolsky and of Brown; and so the three-phase induction motor, that triumph of applied science, came to perfection. Ever since 1891, when at the Frankfort Exhibition there was shown the *tour de force* of transmitting 100 horse-power to a distance of 100 miles with an inclusive efficiency of 73 per cent., the commercial possibility of the electric transmission of power on a large scale was assured. The modern developments of this branch of engineering and the erection of great power-stations for the economic distribution of electric power

generated by large steam plant or by water-turbines are known to all engineers. The history of the electric motor is probably without parallel in the lessons it affords of the commercial and industrial importance of science.

But the query naturally rises: If a steam-engine is still needed to drive the generator that furnishes the electric current to drive the motors, where does the economy come in? Why not use small steam-engines, and get rid of all intervening electric appliances? The answer, as every engineer knows, lies in the much higher efficiency of large steam-engines than of small ones. A single steam-engine of 1,000 horse-power will use many times less steam and coal than a thousand little steam-engines of one horse-power each, particularly if each little steam-engine required its own little boiler. The little electric motor may be designed, on the other hand, to have almost as high an efficiency as the large motor. And while the loss of energy due to condensation in long steam-pipes is most serious, the loss of energy due to transmission of electric current in mains of equal length is practically negligible. This is the abundant justification of the electric distribution of power from single generating centers to numerous electric motors placed in the positions where they are wanted to work.

WHAT PRAGMATISM IS LIKE[1]

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1. *Pragmatism can not be defined*

WHOEVER should define pragmatism in a few words would be doing the most anti-pragmatic thing imaginable. In fact, he who should try to include in a single brief phrase all the tendencies and theories which make up pragmatism would surely be doing something generic and incomplete, and the pragmatists despise nothing so much as vagueness and indefiniteness.

On the other hand, I want you, my readers, to be interested at once in the argument, and love, says Leonardo, is born, and increases with acquaintance. But how shall I proceed? I might give two or three definitions of pragmatism which I have here quite ready, and which reduce all its characteristics and elements to a single one, but I do not feel that I can recommend my wares.

I could tell you, for example, that pragmatism is nothing but "*a collection of methods for augmenting the power of man*," but you could answer that even a manual for tunnel builders would then form a part of pragmatism. Another pragmatist could, on the other hand, assure you that his doctrine is founded upon preoccupation with the future (consequences, previsions), and that therefore it might also be called *prometheism*. You would promptly ask him if books of meteorology, or manuals of prophecy from dreams, or the Utopias of the reformers, form parts of pragmatism.

It would be worse yet if any one should undertake to say that the theory of pragmatism lays stress upon the practical and, in the selection of its doctrines, substitutes the criterion of utility for that of truth. This definition contains much that is true, but one must examine closely what is meant by the practical and by utility, in order that they may gain an undeniable meaning. In fact, what theory is there whose originator does not claim for it practical consequences? What theory would be completely unutilitarian? Theories have a certain sort of utility which coincides with their truth, as, for example, it is commonly useful to hold theories which bring about true previsions. And there is another sort of utility in contrast with this, as, for example, the moral enthusiasm which a belief might give us, even though it were entirely absurd.

[1] Translated by Katharine Royce.

These definitions might be continued, but you would probably arrive at the conclusion that pragmatism, instead of being something new, embraces a vast number of already existing things, and that it is already accepted and practised, consciously or not, by all thinking men.

In this, however, you would be wrong, because, seriously, pragmatism contains new things, and if it is practised by many, it is not recognized or accepted by all. The blame lies with the definitions, since they must not or can not be made as long as books. For definitions, reduced to a single phrase attempting to give an explanation and résumé of the whole, end at best by failing to make really clear that of which they treat. Oftener still, they give rise to embarrassing equivocations and false representations. In order to show the novelty and specific nature of any doctrine whatever, we must come down from the universal to the particular, and fill such large abstract terms as potentiality, actuality, future, etc., with the wealth of special theories and of concrete facts. Without realizing it, I have already given you an elementary first lesson in pragmatism.

2. *What may be expected of Pragmatists*

As soon as I have begun one task, another lies before me. One of the maxims dearest to the pragmatists is this: that the meaning of theories consists entirely in the consequences which their followers may expect from them. To affirm anything actually means this: I foresee that certain things will follow, or that I shall do certain things.

Now apply this maxim to the definition of pragmatism itself, and ask me: What actions or beliefs may be expected from a thinker who is a confessed pragmatist?

That is soon said. These expectations relate almost wholly to his *choices* in the world of thought. That is, we can foresee what things he will love and what things he will hate; what problems he will consider important, and what ones he will reject as useless; what will be his sympathies and antipathies in the world of ideas and of men.

He will seek in every way *not to concern himself* with a great part of the classical problems of metaphysics (in particular with the universal and rationalistic explanation of the sum total of things), which are for him non-existent and senseless problems. On the other hand, he will concern himself strenuously with *methods* and *instruments* of knowledge and action, because he will be sure that it is far more important to improve or to create methods of obtaining exact previsions, or of changing ourselves or others, than to sport with empty words around incomprehensible problems.

His sympathies will be with the study of the particular instance; with the development of prevision; with precise and well-determined

theories; with those which serve as the best instruments for the most important ends of life; with conciseness, with economy of thought, etc.

Naturally he will have an antipathy for all forms of monism; for all universal phrases which signify nothing or too much; for obscure babblings about absurd and inconceivable questions. He will distrust, I say, the pretended evidence and intuitiveness of principles; the faith in a sole and changeless truth; all agnostic theories which make what lies beyond sense a synonym of the unknowable. He will reject all that refuses to change or to adapt itself, all that claims to rule in the name of the divine right of the absolute. He will show no respect or subservience to the famous "reality" of the ordinary man and to the *terre à terre* of the empiricist.

That is to say, the pragmatist scorns those doctrines which pretend to explain the world by means of three or four mysterious phrases in the name of some unique principle. The pragmatist has an equal contempt for those doctrines that humbly cling to brute facts, as experience gives them to us, without trying to extend them into theory (the narrow empiricism and utilitarianism of so-called common sense), or into practise (the ethical evolutionism of "resignation to the laws of nature"). Instead we see the pragmatist kindled by a certain spirit of enthusiasm for all that shows the complexity and multiplicity of things; for whatever increases our power to act upon the world; for all that is most closely bound up with practise, activity, life.

Now if all these characteristics fail to define with sufficient fullness and precision what pragmatism is, yet they may give some idea of its tendencies.

But I can do something more to give precision to these ideas: that is, I can show in what points pragmatism *does not resemble* preceding systems of philosophy.

3. *Pragmatism is not a "Philosophy."*

Pragmatism differs above all from other philosophies through the simple fact that it is not a philosophy, if by philosophy you mean a system of metaphysics, a system of the universe, a *Weltanschauung* or any such matter. The pragmatist, in so far as he is a pragmatist, does not profess idealism rather than materialism, does not believe in the doctrine of creation rather than in that of emanation. For him, *comprehensible* metaphysical theories (and they are not many), can only give rise to *moral* consequences that differ—for the practical and experimental expectations are the same for all. This implies that the most rampant idealist and the timorous materialist would avoid in just the same way an automobile which was about to throw them down; while the beliefs of the former would favor certain moral ideals,

such as pride, nobility, the platonic dream of a world-builder, etc., more than those of the latter would.

For the pragmatist, then, no metaphysical hypothesis contains more truth than another. He who feels the need of one may choose it according to his purposes and his taste in ideas, but he should not greatly flatter himself that his hypothesis can be recognized as the most solid and certain, the best proven and demonstrated.

Pragmatism contains, therefore, no metaphysics, either open or implied. For it, the different theories of the world, properly understood, are but diverse ways of affirming the same commonplace facts, and their value consists solely in their form side, which may be more or less suggestive, more or less favorable to certain aims and preferences of our minds. For the pragmatist, metaphysical theories are facts amongst other facts, and for him the thing that matters is the power of foreseeing the varieties of behavior of the different men who believe in those theories.

From what I have said, it will perhaps seem clear that pragmatism is really *less a philosophy than a method of doing without philosophy.* On the one hand, by striving against problems devoid of sense, such as metaphysics, monism and the like, it diminishes the field of action of that which, historically speaking, is called philosophy; and, on the other hand, by inciting men to act more than to talk, to alter things rather than to contemplate them, to force things actually to exist in a definite way, instead of asserting that they already do so exist, it enlarges the field of action at the expense of pure speculation. Pragmatism would seem to be, then, not only something different from philosophy, but even hostile to metaphysics taken in the traditional cosmological sense.

And the differences do not end here. Another equally important distinction is the *pluralistic* character of pragmatic theories, in contrast with the unity and formal organization of systems created or elaborated by one single mind. A great many do not yet perceive that there *is no such thing as pragmatism,* but that there are only *pragmatic theories,* and *thinkers who are more or less pragmatic.* Let it be understood that among the theories of these thinkers there are affinities and points of contact among their tendencies, otherwise the common adjective would not be justified. But that does not do away with the fact that pragmatism is a *coalition* of theories coming from various sources and temperaments rather than a handsome system sprung from the brain of a single philosopher, or from a homogeneous and well-organized school. If you compare its somewhat chance formation, to which so many men and countries have contributed with rational and well-constructed bodies of thought, such as determinism in the works of Spinoza, absolute idealism in those of Hegel, evolution in those of Spencer, the difference is most plainly evident.

The scattered state of the ideas which have been grouped together under the name pragmatism makes it impossible to find a thinker who is a pragmatist from head to foot. Some people are, even though unconsciously, pragmatical on some points or on certain sides, while they are not pragmatical, or are even anti-pragmatical, on other sides. This spirit of liberty, this freedom from rigidity which the pragmatists have discovered in the sciences exists also in their own doctrine.

4. *Pragmatism is Different from Positivism*

In making this rapid survey of the differences between pragmatism and the philosophies, I have purposely left positivism on one side, because the question of its relation to pragmatism is far more complicated.

In fact, there are those who maintain—either through timidity or ignorance—that pragmatism is nothing but a version, or a trivial revision, of what is known as positivism, or agnosticism. Naturally there are those who say that it is a perfecting, others who say that it is a deterioration of positivism. Mario Calderoni, although he asserts that the name pragmatism expresses "really an advance upon the system of positivism," yet affirms the "fundamental identity" of the two doctrines. In fact, he sees nothing more in the struggle of Peirce against meaningless questions than a simple continuance of the strife of the positivists against metaphysics. Upon this point I do not agree with Calderoni, and I marvel that such a passionate lover of distinctions should not see what differences there are between the two doctrines.

There are two points in which they seem to agree: the importance of prevision, and the rejection of futile and absurd questions. But even concerning these two points there are differences, not to mention others which we shall examine later.

In fact, pragmatism does not consider prevision merely as opening the way to practical applications, or as an aid in verifying theories, but also as a means of *definition* and *interpretation* of the theories themselves. In this case, therefore, such prevision forms a completely new addition to the positivist's method.

Pragmatism, like positivism, condemns and discards the absurd and empty questions which form so large a part of metaphysics, but it does not discard them because they are *insoluble*. That is to say, nearly all the positivists are agnostics, and say that the human mind *can not succeed* in solving these problems. The pragmatists, on the contrary, are all anti-agnostics, and maintain that it is not true that those problems are too *lofty* for our intelligence, but too *devoid of sense*, too stupid, and that their unwillingness to busy themselves with

such matters is not a proof of the impotence, but of the power of our mind. The positivists repudiate metaphysics, but as they do not sufficiently explain *why* they do so, they leave open a way whereby the exiled problems may return. And thus a still graver thing happens, for the lack in their theories, of a sufficiently profound analysis of the methods of science and of philosophy, gives the metaphysical spider a chance to spin its web once more even within themselves and in their own thought. This may be seen in even the best representatives of positivist methods, for these, while raising their voices upon all occasions against vain and empty metaphysics, yet do not perceive the poor and feeble metaphysics in their own books and discussions. Agnosticism, monism, materialism, evolution, which are almost always associated or confused in the minds of the positivists, are metaphysical doctrines which presuppose in their turn metaphysical premises. Agnosticism implies the belief in a world more real than ours. Monism appeals to universal and unthinkable conceptions. Evolution supposes a sort of providential plain of the universe, and so on. Positivism, then, is only *anti-metaphysical in words,* while pragmatism is *anti-metaphysical in substance.*

And the differences do not end here. There are in pragmatism at least three tendencies which in agnostic positivism do not exist at all, or at best only in the germinal state.

First of all is the principle of the *economy of thought,* traces of which may more easily be found in Occam and Leibniz than among the positivists. Secondly, the resurrection of the Baconian axiom "knowledge is power," that is, the demonstration of the part played by the idea of power and the possibility of power in our beliefs and theories. Finally, the *emancipation of thought, both from immediate facts and from pure rationalism.* Both are shown in pragmatism, not only by its theories about the free "creation" of facts, and of hypotheses in science, but also by its views concerning the non-necessity, for deduction, of the premises being "rational." That is to say, its willingness to start from absurd or fanciful hypotheses, in building up new theories and new sciences. It seems to me, then, that this is enough to justify the separation of these two lines of thought under distinct names, the more so since it can be shown historically that the differences between positivism and pragmatism are much greater than those which existed between positivism and the earlier so-called "English philosophy." Pragmatism may indeed continue on certain lines the work of some of the best positivists, but it may claim, when closely considered, to be really made up of differences from positivism. It would be hard to differ more than that!

5. *Why it is Good to be a Pragmatist*

After all this talk my readers probably begin to see what it means to be a pragmatist, but it would not surprise me to hear some one say: Then, since it seems the pragmatists prefer theories that are of some use, tell us, please, what is the use of being a pragmatist.

The answer, after what I have said, is not difficult. The spiritual gains of one who is or becomes a pragmatist are not to be despised. The first is a *gain of time,* for the pragmatist gives a definitive *quietus* to the so-called "insoluble problems," the pretended "enigmas of the universe," which are merely non-existent or ill-stated problems that become soluble when stated in the pragmatic way. The time thus saved can be used either in the study of other problems, or in the practical application of theories that have been already verified by experience.

The second gain is the *mental stimulus* given by the consciousness of our human control over scientific conceptions, and over our own minds, and by the feeling of the plasticity of truth and of the opening of ever-wider spheres of possibility offered to the deductive imagination, and to the powers of the human soul over the universe.

This economy of time and strength and this increase of satisfaction and enthusiasm will suffice, I should think, to content those who have any intention of becoming pragmatists. If these do not suffice I will point out other advantages. Pragmatism having the characteristics of a *thing not yet finished,* not completely worked out, not fixed and crystallized, can therefore offer to him who turns to it the possibility of developing and transforming it, that is, of being not merely one of its followers, but at the same time one of its creators. Pragmatism thus offers the advantage of not being in itself a metaphysic, but of permitting the esthetic or moral enjoyment of possible or actual metaphysics.

6. *Who will become Pragmatists?*

There is one last question that could be asked. Who are the men who most readily become pragmatists? Is it possible to predict what classes of minds are the most disposed to receive the teachings of pragmatism?

In order to answer, I should perhaps have to build up the psychology of the pragmatist type. For theories, even the purest and abstractest, have their actual ground and source in biological needs, and in the deepest sentiments of the general human race, or of particular exceptional persons.

This conception of Nietzsche—which the pragmatists have taken up and unfolded—of the vital and moral sources of "pure thought," so-called, shows us, when applied to pragmatism itself, the three groups

of sentiments which are to be found hidden in the souls of the pragmatists. The first group is that of our *vital sentiments*, that is, of our instinctive desires for a larger and richer life, for more extended power. Our love of the concrete, of real and particular things, comes in here, as well as our fondness for dreams that "come true"; also our hatred of useless words, and of dreams foisted upon reality, that neither let us contentedly accept it, nor enable us to alter it.

The second group may be called the *pessimistic sentiments*. These are shown in the tendency to wish to change all existing things, facts and theories. Another manifestation of this is a certain aversion to anything that comes to us claiming to be already complete, and forces itself upon our acceptance, whether it call itself scientific hypothesis or law of nature.

The third group, on the contrary, is optimistic in its character. It consists in *sentiments of pride*. These are shown in our honorable reluctance to accept things ready-made, instead of making them for ourselves; in our unwillingness to receive our intellectual inheritance without right of appeal or revision. They are also shown by the dislike of submission to what men call the inevitable, the unchangeable, the eternal, and by the proud hope of being able to change existing things by means of simple spiritual force.

To come down from this hypothetical psychology to a more exact forecast, I believe, in general, that all those who think in order to act, who prefer provisional truths that work to over-abstract terms, however intoxicating, may be in sympathy with pragmatism.

Excluded beforehand, consequently, are all pedants devoted to fixed formulæ, all systematizers who see the world under the despotism of a symbol; all lovers of immutable truth, of pure reason, of transcendental conceptions, in a word, all conservatives of a rationalistic complexion. But there are, in particular, two classes of minds that seem to me destined to form the bulk of the pragmatist army. I mean practical men and Utopians. The first, because they find in pragmatism the theoretical explanation of their scorn for questions that have no sense or practical import, and of their sympathy with all that is clear, potent and unencumbered. The second, because they find in pragmatism suggestive points of view that encourage them to imagine and to hope extraordinary things. The ideas of pragmatism about absurd hypotheses, about imaginary sciences, about the influence of the will upon belief, and of belief upon reality, seem made on purpose to stimulate the poets and dreamers of the world of thought. Thus pragmatism, in this sole point resembling the Hegelian dialectic, succeeds at last in reconciling opposites.

THE PROBLEM OF AGE, GROWTH AND DEATH

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IV. Differentiation and Rejuvenation

Ladies and Gentlemen: In order to present the subject of this evening, I will take a few brief moments at the beginning to review the results reached in the previous lecture. In the last lecture I spoke of the phenomena of growth, and endeavored then to make clear to you what I consider the fundamental conception of this study —that the decline in the growth power is extremely rapid at first and slow afterwards. This change in the rate of growth is of course due to things in the animal body itself. It is a logical conclusion for us to draw that if we are to study out the cause of the loss of growth power, we should do it rather at that period of development when the change in the rate of growth is most rapid, for then we should expect those modifications to exhibit themselves most clearly because the magnitude of cause is likely to be proportionate to the magnitude of result, and when the decline is most rapid, then we must expect to find the alterations which cause that decline in the organism to show themselves most conspicuously. You will remember, further, that we spoke of growing old as being a much more complicated question than one of growth alone, and that there occur, as the years advance, changes in the structure of the body. It is convenient to use one collective term for all these phenomena of becoming old, and that term, established by long usage, is *senescence,* the becoming old. What, therefore, we have to search for at present is a cause, a proximate cause at least, of senescence. In order to make the view I am to bring forward this evening quite clear to you, I must first of all take advantage of your kindness and recapitulate briefly what I said in regard to cells, for you will remember that the cell is the foundation and unit of organic structure. With your permission I should like to recall more exactly to your minds what I said of the cells by having thrown upon the screen the slide which we saw before and which we used as an illustration of the cell. Here is the picture. Above we see the typical cell from the oral epithelium of the salamander, and you remember in the center this more conspicuous body with a granular and reticulated structure which we called the nucleus, and surrounding it is this mass which we called the body of the cell, or the protoplasm. Here is an-

other condition of a cell of the skin of the salamander in which the nucleus presents a slightly different appearance. Here also we have quite a body of protoplasm about the nucleus. Every cell consists of these two essential and fundamental parts, the nucleus and the protoplasm. Now the conclusion to which I shall gradually bring you by

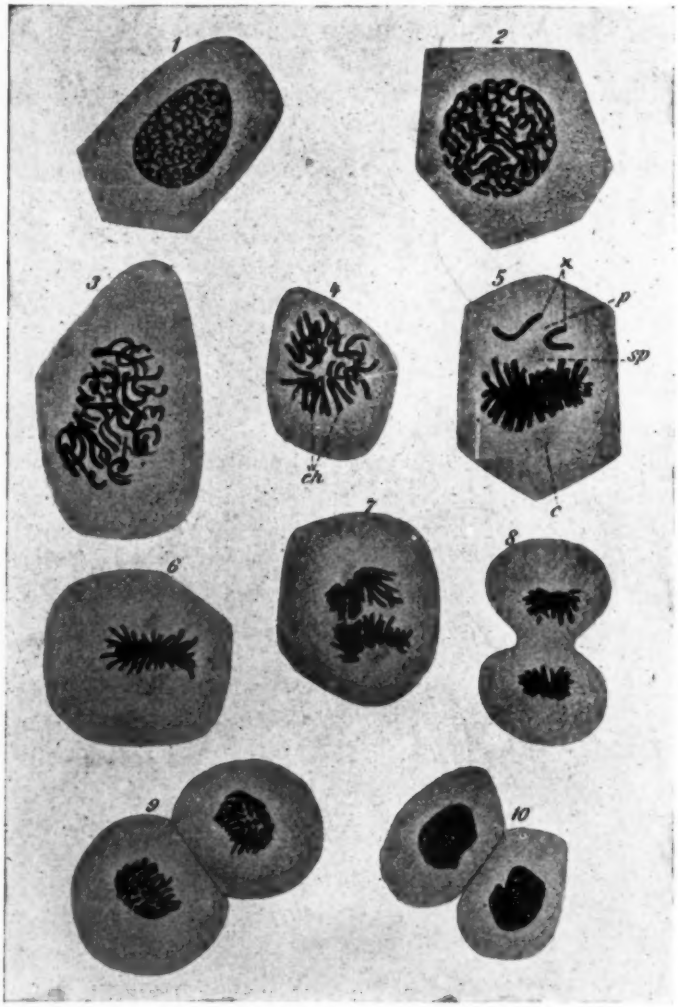


FIG. 39. CELLS FROM THE MOUTH (ORAL) EPITHELIUM OF THE SALAMANDER.

the facts to be laid before you this evening is that the increase of the protoplasm is the thing which is to be regarded as the explanation of senescence. Though protoplasm is the physical basis of life, though it is the actual living substance of the body, its undue increase beyond the growth of the nucleus changes the proportions of the two, and that change of proportion seems to cause an alteration in the conditions of

the living cell itself, and that alteration I interpret, as I shall explain more accurately later, as the cause of senescence, as the fundamental cause of old age. This slide also shows to us the early development of the cells through those phases which result in the multiplication of them. The nucleus changes in appearance and becomes a very different-looking structure. These changes I need not now go through again. Suffice it to say that after the complicated alterations have completed their cycle, we get in the place of a single cell, two, and

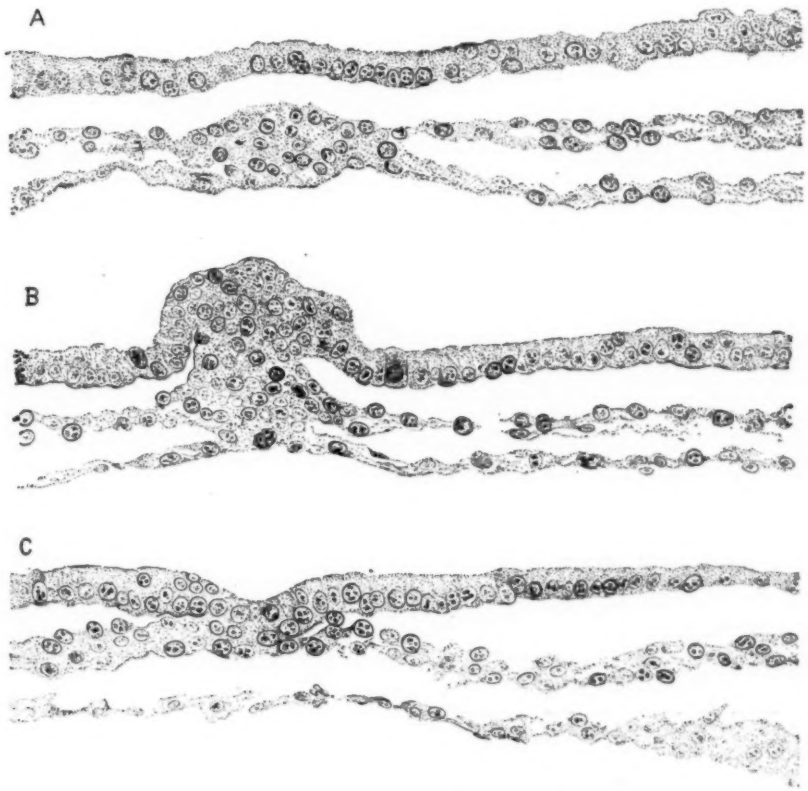


FIG. 40. THREE SECTIONS THROUGH A RABBIT EMBRYO OF SEVEN AND ONE HALF DAYS.

each has its own nucleus, and each its own protoplasm. Notice here that the two cells which finally result are smaller than the original cells from which they sprang. These are by no means imaginary pictures, but accurate microscopic drawings from real cells of the salamander skin. The two cells which are thus produced from one parent cell are characterized by their smaller size, and this smaller size applies not only to the cell as a whole, but likewise to its nucleus. After having been thus reduced in size, the nuclei and the cells will both expand, and soon the daughter cells will return to the mother dimension and be as large as the parent cell from the division of which

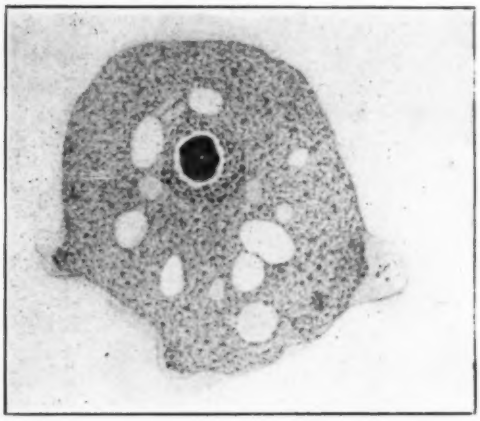


FIG. 41. *Amœba coli*, HIGHLY MAGNIFIED. Drawn from a cover-glass preparation from a twenty-four hour culture.

they arose. There is thus, we learn, the constant fluctuation in the size of cells, a fluctuation in their dimensions accompanying the process of cell division. Presently we shall have more to say in regard to this matter of the change in the cell in size. The next picture (Fig. 40) which I want to recall to you is one which we also had in an earlier lecture. These represent slices through a very young rabbit before any of the organs of the rabbit have begun to develop. We can see here clearly the nuclei, as I pointed out to you before, nearly uniform in structure, and you notice that the protoplasm around each nucleus is quite small in amount. If you will recall the previous picture of the skin of the salamander, upon the screen a moment ago, you will realize immediately, in comparing the two, that in these young cells the proportion of the protoplasm to the nucleus is very small. That is again one of the fundamental facts to which we shall recur in a moment. I wanted to show you this picture in order to revive in your minds the conception which I endeavored to give you before of the undifferentiated tissue, where the cells have nuclei pretty

FIG. 42. TERTIAN MALARIAL PARASITE. Two human blood corpuscles alongside and drawn on the same scale.

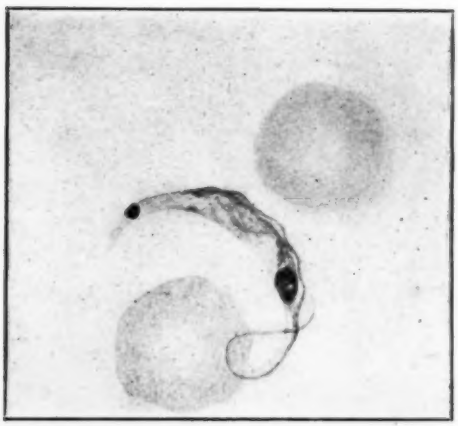


FIG. 43. *Trypanosoma Lewisi*, from the rat's blood with two blood corpuscles alongside drawn on the same scale.

uniform in appearance and in size, each with its little mass of protoplasm about it, and this protoplasm appearing in all the cells under microscopic examination very much the same. We can not in this stage of development say of a given cell that it represents any special structure, by which, if we saw it isolated under the microscope, we could determine from what part of the young embryonic body it was derived. When we see a cell from the adult we can determine its origin with certainty by its microscopic appearance alone. As development progresses, the simple condition of the cells is gradually obliterated, but we find another condition arising which we call the differentiated one. Differentiation is a process which goes on in the body as a whole, but of course it is also a function of each individual cell. We can see something of the process of differentiation if we study the unicellular organisms, those creatures, each of which is complete in itself, although it consists of but a single cell, not of countless millions of cells as we do. The picture (Fig. 41) which I have chosen to throw upon the screen is one which I think might have an additional interest to you, for it is a photograph from the living cell known as the parasite producing dysentery. Its scientific name is *amœba coli*. It is a photograph from life. Here vaguely in the center, marked with a finer granulation, and some of the darker spots in it, we can distinguish the nucleus: here is the outline of the protoplasm of this cell, and in it are included some particles of food which this protoplasmic body has absorbed for purposes of digestion. This is a unicellular parasitic organism with scarcely any differentiation of its structure. The next of the slides shows us again another of these parasitic simple organisms. The figure here to the right of the field of view is the one which should especially attract your attention. The other two bodies near it are blood corpuscles, human blood corpuscles. The organism in this case is the one which causes malarial fever, and it is in a particular stage of its development; that which we distinguish as the tertian malarial parasite is the one here represented. You can see in this case also the outline of the nucleus, surrounded by the protoplasm—the whole thing only a little bigger than a single human blood corpuscle. Here also we note the absence of differentiation. Another stage of this same tertian malarial parasite is shown next. This I have projected upon the screen because it illustrates more clearly than the other the nucleus and the small amount of protoplasm about the nucleus. The malarial organism is one of great vitality, capable of enormously rapid multiplication, and it undoubtedly owes that faculty to its constitution, to the relation between the nucleus and the protoplasm. I will now show you another picture of parasites—one form of which, in a related species, occurs in man. This particular form is one which occurs in the rat and is called the *Trypanosoma*. You can see that the body, instead of being a small and simple struc-

ture, has elongated, acquired a peculiar form, and here in the interior are lighter and darker spots. These do not show very clearly in the picture, because it is from a photograph of a living specimen under the microscope. The lighter and darker spots correspond to the details in the structure of the organism. Here is the tail of the organism, twisted, as you see, and in life capable of being bent. The movement of the animals in the natural fluid in which they are suspended is quite active. Alongside are some blood corpuscles, the figure, as you see, is magnified about the same as the one of the malarial parasite which I showed you a few moments ago. The next slide exhibits an

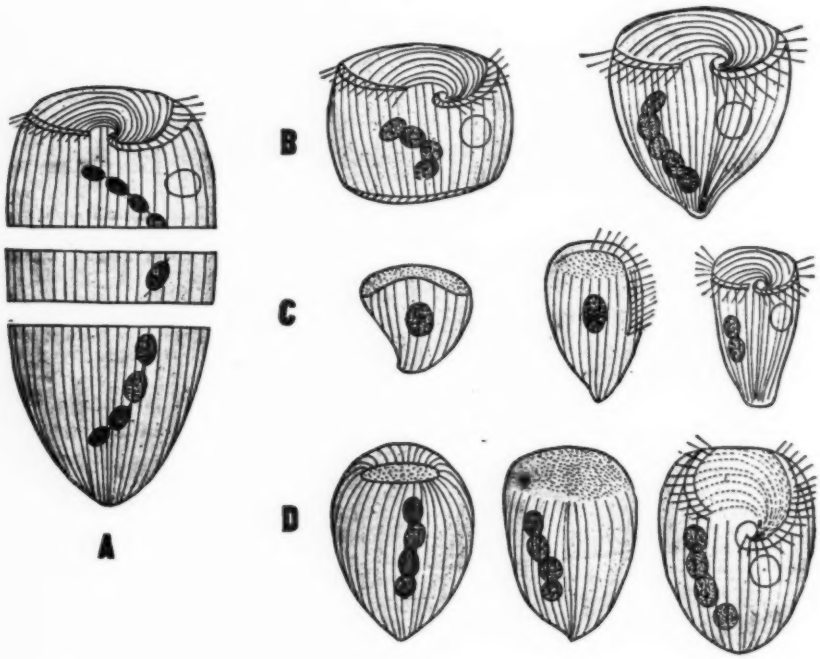


FIG. 44. *Stentor cœru'eus* *A*, cut into three pieces; *B*, regeneration of the first piece; *C*, of the middle piece; *D*, of the posterior piece. After Gruber.

organism which swims free in the water, and is pretty well shown in this figure. It is called the *Stentor*. Here the chain of beads represents the nucleus. Upon the surface of the body there are fine lines indicating superficial structure. At this point there occurs what we call the mouth. Over the rest of this minute organism there is a thin cuticle, but at the mouth the cuticle is absent, and the protoplasm is naked or uncovered so that food can be taken in. There are bands of hairs showing coarse and stiff in the figure but capable of movement, and with the aid of those vibratile hairs, or cilia, the organism can swim about in water. Here is another internal structure, the vacuole; obviously in an animal like this we no longer have simple protoplasm

alone, but the protoplasm in the interior of the cell has become in part changed into other things. Here then within the territory of a single cell we have differentiation. If now in these unicellular organisms we study both the protoplasm and the nucleus, we learn that most of these modifications which are so conspicuous upon microscopic observation are due to changes in the protoplasm. It is the protoplasm which acquires a new structure. In the nucleus, on the contrary, we find perhaps a change of form, minor details of arrangement by which one sort of nucleus, or one stage of the nucleus, can be distinguished from another, but always the nucleus consists of the same fundamental constants. There is the membrane bounding it; there is the sap or juice in the interior; the network of living threads stretching across it; and here and there imbedded in and connected with this network are the granules of special substance, which we call chromatin. These four things exist in the nuclei and are apparently always present, and there is usually not to be seen in the nucleus anything of change comparable, in extent at least, with the change which goes on in the protoplasm—on the other hand, the protoplasm acquires items of structure which were totally absent from it before. The nucleus rearranges its parts rather than changes them. This is a very important fact, and shows us, if we confine our attention even to these little organisms only, that the differentiation of the protoplasm is *quantitatively* the more important of the two—the differentiation of the nucleus the less important.

We can now turn from a consideration of these lowest organisms to the higher forms, among which we ourselves of course are counted, in which the body is formed by a very considerable number of cells. Again I should like to take advantage of your kindness and show you some of the pictures we have already reviewed, in order to utilize the features which they show as illustrations of the fundamental principle that the conspicuous change is in the protoplasm. Here we have nerve cells. In the first two photographs are represented two isolated nerve cells, to show their shape. They have been colored by a special process so dark that the nucleus which they contain in their interior is hidden from our view; it is of course none the less there. This dark staining enables us to trace out the shape of these cells very clearly, and you can see that instead of being round and simple in form they have their elongated processes stretching out to a very considerable distance; these processes serve to catch up from remote places nervous impulses and carry them into the body of the cell, and thus assist in the work of nervous transmission. The elongation of these threads is, as you see, adapted, like the elongation of a wire, to long-distance communication. Here are two other figures which represent nerve cells treated by a different process, and again artificially colored. But the color in this case has attacked certain spots in the protoplasm,

consequently we see that the protoplasm around the nucleus in both of these figures is no longer simple and uniform, but contains these deposits of dark-colored material. Here are other nerve cells; the one

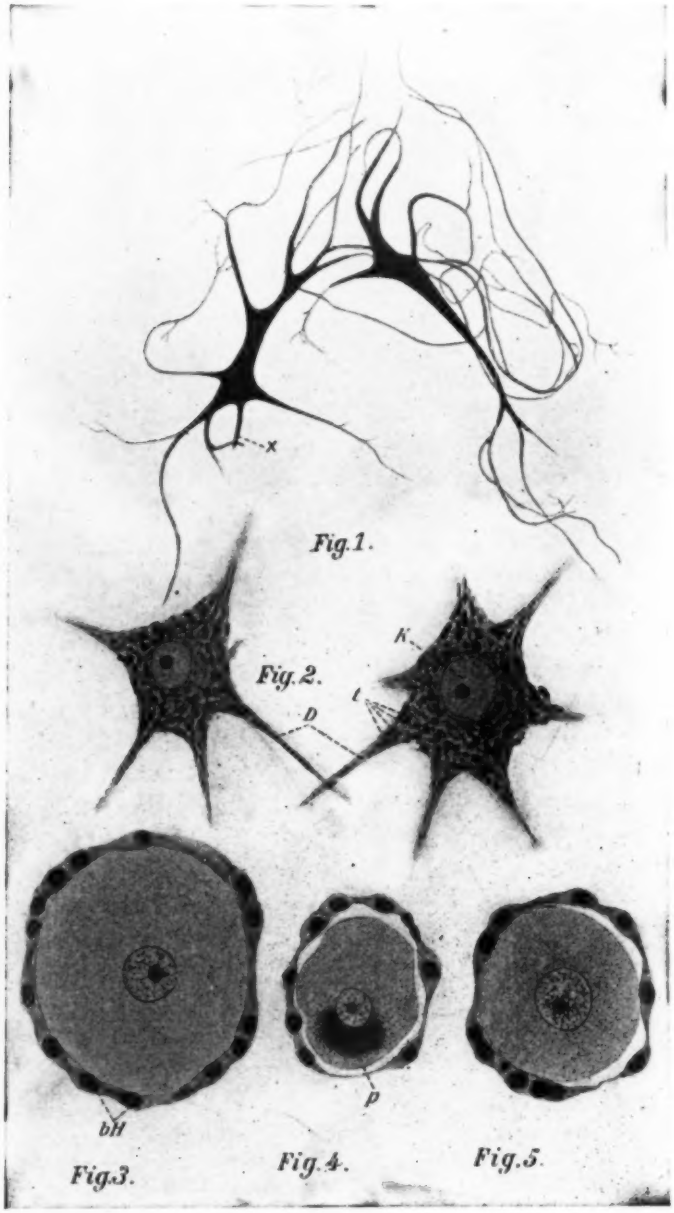


FIG. 45. VARIOUS KINDS OF HUMAN NERVE CELLS. After Sobotta.

in the center shows you the accumulation of pigmented matter in the protoplasm; again an index of a change and lack of the previous uni-

formity replaced by diversity in the composition of the various parts of the single cell. This figure shows us more clearly the principle of structure of a nerve cell, for here we have the central body of the cell composed of protoplasm with its nucleus in the middle and a small spot in the center of the nucleus, and these long branching processes running out in all directions which can take up nerve impulses from other similar or dissimilar cells, as the case may be, and carry them to the central body. To carry the message out there is typically but one process, which is different in appearance from the other processes which carry the impulses in. The latter are branching and are therefore called the tree-like or dendritic processes. Here is a single process like a long thread to carry the impulses away, and which

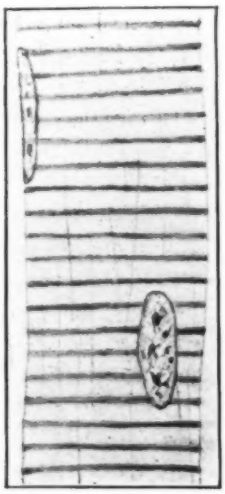


FIG. 46. PART OF A HUMAN MUSCLE FIBER.

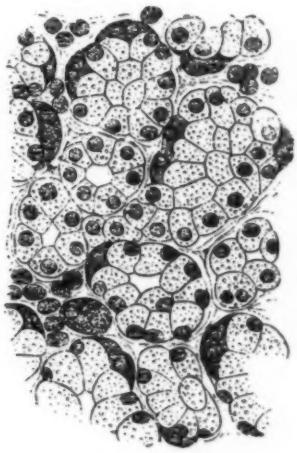


FIG. 47. SECTION FROM AN ORBITAL GLAND.

is called the axon of the nerve cell. In this case the modification of the shape of the cell has adapted it to the better performance of its functions. Notice also in these cells the enormous increase in the amount of protoplasm as compared with the nucleus. In the young cell of the rabbit germ, of which I showed you several illustrations a few moments ago, we had very little protoplasm for each nucleus, but here the protoplasm has many, many times the volume of the nucleus, and this is a relatively old cell.

Next let us look again at the figure of the striated muscle fiber, which you may recall from the second lecture, so that it will suffice if your attention is again directed to the oval nuclei, and to the lines stretching crosswise on the muscle giving it a "striated" appearance. You remember, doubtless, that such fibers are the ones which enable us to make voluntary motions. Originally each fiber was a set of

cells, and the cells had some protoplasm, but, gradually, as development progressed, there appeared in them longitudinal fibrils different from the protoplasm, and the fibrils also created ultimately the appearance of cross lines on the fiber. It is the fibrils which perform the muscular contractions. It is not the original unmodified protoplasm, but the modified or differentiated muscular cell which is capable of voluntary contraction.

The next picture (Fig. 47) shows us clearly and strikingly how much the differentiation may vary. We have here another type of differentiation. These are gland cells; we can see here, as I pointed out to you before, the material in the form of granules, which is to produce the secretion from these gland cells. This is an orbital gland, and here are the cells, which are very much smaller because they have discharged their secretion. Three of the cells are represented separately. The first shows us a cell full of the material which is to be discharged and is to form a part of the secretion of the saliva. The second is a cell which has partly lost its accumulated material, and the third is one which has discharged it almost completely, so that it has become very much reduced in size. We learn from such structures as these that the size of cells may vary also according to their functional condition. We have here a similar gland. This is sometimes called the salivary gland of the intestine, better termed the pancreas. Here we can see for each of these cells a nucleus and a body divided into two parts, a darker portion around the nucleus and a lighter part with little granules in it, which represents the accumulation of material which is to form the secretion. When the cells have discharged their secretion, they, like the cells in the salivary gland, are found to have diminished in size and become very much smaller indeed than they were in their earlier state when charged with the zymogen destined to be given out. In this case also we have an illustration of a functional variation in the size of the cells. This ends the series of pictures which I wanted especially to show to you as illustrating the changes of the cells as their differentiation progresses. We can see in the bodies of the cells the changes which have occurred.

Here is a picture which teaches us one thing more about these cells. Notice the scattered nuclei, each surrounded by protoplasm, completing the cell. The protoplasm of each of these cells is connected across with the protoplasm coming from another, so that the whole set of cells forms an irregular protoplasmic network. Now in the spaces between these cells are fine lines. These represent delicate structures which we call connective tissue fibrils, which have a mechanical function. By their tensile strength, their power to resist and pull, they give a certain supporting power to the tissues. Our picture represents one of the tissues which support and connect other portions of the body. Now the fibrils apparently lie entirely disconnected from

the cells, but a more careful study of the history of the connective tissue has revealed the very interesting and instructive fact that the fibrils, now separate from the cells, arose by a metamorphosis of the protoplasm of the cells—that they are first formed out of some of the protoplasm of these cells, then split off from them, and come to lie in the intercellular regions, so that here we have another type of cell differentiation brought to our notice, one in which the product is separated from the parent body to which it owes its origin. Now you will perceive immediately, if you recall the series of pictures which have just passed before us on the screen, very great differences in the types of differentiation which occur in the body, and had we time we might find a very much larger range easily to be represented before us.

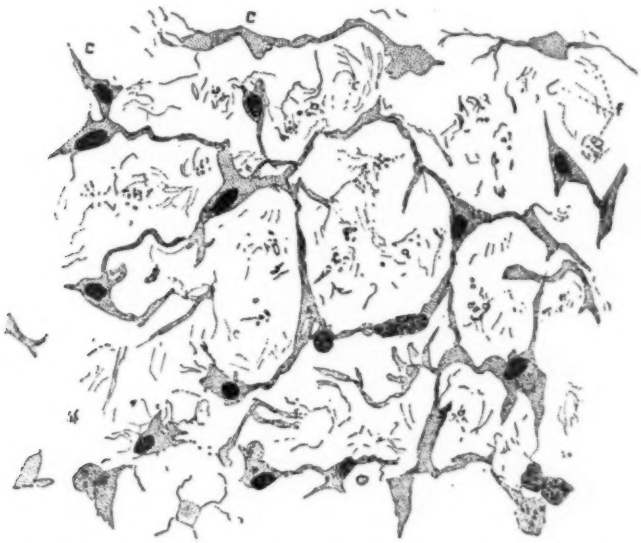


FIG. 48. EMBRYONIC SYNCYTIUM FROM THE UMBILICAL CORD OF MAN; *c*, *c*, cells; *F*, fibrils.

In the second lecture a picture was projected upon the screen, which showed motor nerve cells of various animals. You will recall that I directed your attention to the fact that the largest animal, the elephant, has the largest cells, and the smallest animals, the rat, the mouse and the little bat, have the smallest ones. But let me point out to you that the question of the size of cells is exceeding complex, and that in studying it we have to exercise a great deal of caution. We know that, with the exception of the nerve cells and to a minor degree with the exception of the muscle fibers, the cells in each animal are more or less uniform constants in size. The cells of different organs differ somewhat from one another. A single organ may have in its different parts typical sizes of cells, but each of these kinds of cells has its definite dimensions. When one animal is larger than another,

it has more cells. Now it is a very important fact for us that animals have a more or less constant size of their cells. They do not differ from one another by a difference in the size of their cells; the bigness of an animal does not depend upon the size, but upon the number, of its cells. We can, therefore, in studying the changes of size, to which I shall next direct your attention, omit altogether these details, and speak of the cells in a general way safely as having a certain uniform or standard size. This will save us a great deal of time, for we learn, as we study cells, that their size increases with the age of the animal. The animal, when it is young, has cells with a small amount of protoplasm. And that, you will perceive from the pictures which have been thrown upon the screen, is an absolutely necessary corollary of the discovery that differentiation is mainly a function of the protoplasm. If there is to be a large degree of differentiation it is necessary that the quantity of protoplasm in the single cells should be increased, so that there may be the raw material on hand out of which the differentiated product can be manufactured. If there is not such a preliminary increase of the protoplasm, then the differentiation can not occur. In order that perfection of the adult structure should be attained, it is necessary that the mere undifferentiated cells, each with a small body of protoplasm, should acquire first an increased amount of protoplasm, and that then from the increased protoplasm should be taken the material to result in differentiation, in specialization.

An undifferentiated cell performs all the fundamental functions of life. An amœba, or any unicellular organism such as I have presented to you upon the screen, does everything which is indispensable to life. It takes food; it forms secretions and excretions; its activity depends upon chemical alterations going on in the food in the interior of its body: it is capable of sensation and of locomotion. It is probable that every living cell has all of these fundamental properties of protoplasm. When a cell becomes differentiated, however, though it does not necessarily give up any of its vital properties, it becomes different from other cells because one of its properties is made conspicuous. And in order to acquire that conspicuousness, that excess of development of one function of the cell, a modification in the structure is necessary. The apparatus in the interior of a cell to produce the exaggeration of the function must be developed, so that to effect the complex physiological machinery of the adult body, this differentiation, of which I have so often spoken, is indispensable. A nerve cell carries on all the vital functions, but it has in addition a special series of modifications of its protoplasm which enable it to accomplish the transmission of the nervous impulses with greater efficiency than ordinary protoplasm can do, probably at a higher speed and with a more perfect adjustment of communication between the various parts of the body than is possible with any machinery of pure protoplasm. So

too, the glands have cells which are especially capable of elaborating chemical substances which, when they are poured out, accomplish the work of digestion, for instance. But these cells are likewise alive in all their parts. They have all the fundamental vital properties, but there is this tremendous exaggeration of the one faculty, and that involves an alteration so great in the protoplasm that we can see it with the microscope; the microscope affords us a perfect demonstration of differentiation, which we can correlate with the function.

The primary object, therefore, of all differentiation is physiological. The higher organism, with its complex physiological relations, is something really higher in structure than the lower organism. The term "higher" in biology implies a much more complex interrelation of the parts, a much more complex relation of the organism to the outside world; and above all it implies in the highest animals a complex intelligence of which only a rudimentary prophecy exists in the lowest forms of life, possibly scarcely more than a mere sensation. We owe then to differentiation our faculties, which we prize. It is the result of differentiation that I am able to address you and present before you the thoughts which have been accumulated as the result of the studies of many years. It is a result of differentiation that you have such parts that you not only hear the actual sound of my voice, but interpret—at least I hope so—the meaning of my words and can understand the ideas which I am endeavoring to present to you. If you carry away something from these lectures, and recall it at some future time, that also will be a result of the differentiation of structure; for every one of you started as a minute germ, consisting of protoplasm with a nucleus, and entirely without any differentiation; and by a process so complex that the mystery of it escapes entirely all our powers of analysis, those parts which you have have been slowly and secretly fashioned. We have approached one of the fundamental problems of existence. When we talk of differentiation, we talk of the endowments which bring us into relation with the external world—into relations with our kind, and which make our internal life so complex, a complexity which in itself is a great problem. We touch here the fundamental mysteries of existence; we are hovering upon the outskirts of our human conceptions. We are not yet able to press beyond. But perhaps the time may come when the limit to which I can now bring you will be moved farther back, and some of the things which are at the present time utterly mysterious and incomprehensible to us will be comprehended and be explicable to you.

The increase of the protoplasm is then, as we have clearly seen from the pictures, the mark both of advancing organization and of advancing age. It is certainly somewhat paradoxical to assert that the increase of the protoplasm is a sign of old age, a sign of senescence, since protoplasm is the physical basis of life. It undoubtedly is such,

and we should hardly anticipate that its increase would have a deleterious effect. But such is, it seems to me, clearly the case. But it is not merely, of course, a question of the increase of protoplasm which we must bear in mind in estimating the cause and effect, but also the question of differentiation, in consequence of which protoplasm becomes something else and different from what it was before. This alteration, then, together with the increase of the protoplasm, is the change which in all parts of the body marks the passage from youth to old age.

It seems to me not going at all too far to say that the increase of protoplasm is a fundamental phenomenon. I wish to give you a more precise notion of this increase; and I am glad to be able to do so in consequence of a research carried on by Professor Eycleshymer in my laboratory and completed by him afterwards in his own laboratory at the University of St. Louis. He studied the development of the muscle fibers in the great salamander, known scientifically by the name of *Necturus*. These muscle fibers are somewhat cylindrical in shape. Their ends can be accurately determined so that the precise length of a fiber can be measured, and its diameter also. Hence the total volume of a fiber may be calculated. It is possible also to measure the nuclei and to count the number of nuclei in a fiber. Thus by measuring the diameter and length of the fiber, and then estimating the number and the diameters of the nuclei, we can calculate the proportions. As a matter of fact, the nuclei remain nearly constant in volume, not really quite so, but sufficiently constant to serve as a basis of measurement. Dr. Eycleshymer found that when a *Necturus* had a length of eight millimeters, it possessed, for each nucleus in its muscle fiber, 2,737 units of protoplasm, but when it was seventeen millimeters, it possessed for each nucleus 4,318 units per nucleus; at twenty-six millimeters, 8,473 units; and in the adult, which measures approximately 230 millimeters, it has 22,379 units per nucleus. In other words, as a salamander passes from the eight-millimeter condition, when the development of its muscle fibers is just fairly begun, up to the adult state, when the differentiation of the muscle fibers has been completed, it increases the proportion of protoplasmic substance and protoplasmic derivatives from 2,700 to 22,300 per nucleus. I give round numbers. The increase is approximately sevenfold. There is in the adult in the muscle fiber seven times as much protoplasmic substance in proportion to the nucleus as there was at the start of development when the muscle fiber could first be clearly recognized as such. This is an accurate measure and gives us a good idea of the general law of protoplasmic increase. It is the only instance, I yet know of, in which we have an accurate measure and can give quantitative values, though we do know that there is a more or less similar increase occurring in perhaps every tissue of the body.

While the increase of the protoplasm is going on, we find that there is an advance in the structure, in the differentiation. Now you may recall what I have mentioned earlier in this lecture, the further fundamental fact that the loss in the rate of growth is greatest in the young, least in the old, and that as we go back from old age towards youth, and then into the embryonic period, we find an ever-increasing power of growth, but that it is during the embryonic period that the loss of the power of growth is greatest. It is to the embryonic period, therefore, that I have turned in order to ascertain whether the rate of differentiation shows a similar relation in the development of the organism.

We have a large series of microscopic preparations of rabbit embryos in the embryological laboratory of the Harvard Medical School. Utilizing these, I found that at seven or eight days of development there is scarcely a trace of differentiation. The cells are in the condition of those which I showed to you earlier in the lecture upon the screen. At sixteen and a half days, a stage of development of which I have some good preparations, I found that a great deal had been accomplished. At seven days there was no brain, there was no spinal cord, nothing that could possibly be called skin or muscle, or intestine or heart. None of those things were yet produced. But at sixteen and one half—in other words, after a very brief period indeed—only nine days of the whole life of the animal—there have arisen from this inchoate beginning all the principal organs of the body. The brain is there, divided up into its principal fundamental parts; the spinal cord has its nerves in connection with the various parts of the body; there is a trace of the skeletal element; the stomach, the liver, the pancreas, the intestines, are all present and well defined; the heart is a large and beating organ, amply supplied with blood, connected with vessels, which carry out and bring back the blood and are all far along in their development. Equally instructive is the microscopic examination, for we can see that the cells themselves have been changed. Not only have the great organs been mapped out in this brief period, but the cells which belong to them have for each organ acquired a characteristic quality. In the brain there are nerve cells with their long processes to carry the impulse in; the single process (axon) to carry it out. The glands in the stomach have the cells which are to build them already there. The muscles which are to move the stomach are beginning to appear as cells of a special form. Nerve fibers extend down into the gastric region and to the various distant organs of the body. Muscle fibers can be recognized along the back and in the limbs, and so in every part of the body we can detect cells already far advanced in their development. It is not certainly too much to say that in the brief period of these nine days fully as much differentiation has been accomplished as is accomplished during the entire remainder of the life of the animal. We do not, at present at least, possess any method of measuring dif-

ferentiation, which enables us to state it numerically, but no one who is familiar with these matters and observes the structure, as I have myself observed it, would hesitate for a moment, it seems to me, to decide that my assertion is perfectly within the bounds of truth, that within a period of nine days, half of the entire differentiation which is to occur in the whole life of the rabbit has been completed. We must from this conclude that the rate of differentiation is very rapid at first and afterwards declines, and as we compare the different stages of development we can see readily that this is the case. The progress in the additional development in the rabbit from sixteen and one half days up to the time of its birth is far greater than the progress which occurs after birth. We find, moreover, in the study of these embryonic conditions, some instructive things, for in certain parts of the body the process of differentiation hurries along, and as the cells are differentiated their power of growth, to a large extent, is stopped. On the other hand, there are various provisions in the developing animal for keeping back certain cells, allowing them to remain in the young state. Such cells may afterward differentiate.

From all that has been said it seems to me legitimate to conclude that there is an intimate correlation between the rate of differentiation and the rate of growth. I am inclined to go the one step farther, and bring them into the relation of cause and effect; and I present to you as the main general conclusion of this first part of our series of lectures, the conception that *the growth and differentiation of the protoplasm are the cause of the loss of the power of growth.* Now if cells become old as their protoplasm increases and becomes differentiated, we should expect to find that there would be a provision for the production of young cells. It is rather mortifying to reflect that the simple conception which I have now to express to you, although it lay close at hand, failed to combine itself in my mind for many years with the conception of the process of senescence as I have just described it to you. It is somewhat, it seems to me, like two acquaintances of mine who lived long side by side, seeing one another frequently until they were fairly past the period of youth, when their attachment became very close and by a sacrament they were permanently joined together. So in the minds of men often two ideas lie side by side which ought to be married to one another, and there is no one ready, so dull is the owner of the mind, to pronounce the sacramental words which shall join them, and the rite long remains unperformed, and when at last such neighbor ideas, which naturally should be united in close companionship, are brought together and made, as it were, into one, we are astonished that the inevitableness of the union had not obtained our notice before, it is so very obvious. And so in regard to the conception of what constitutes the restoration of the young state, I have only this excuse to offer, which I have indicated to you, that even the

natural thought fails to occur to us. We are very dull even if we are scientific.

The pictures now before you represent certain early stages in the progress of development of a mammal by the name of Tarsius, a creature related to the lemurs. The various figures illustrate the multi-

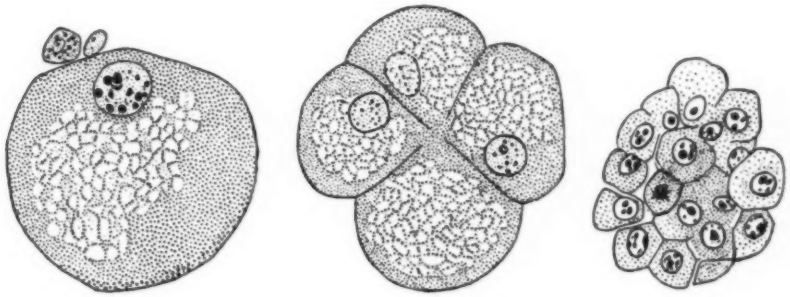


FIG. 49. *Tarsius spectabile.* SECTIONS OF THREE OVA IN VERY EARLY STAGES. 1, before cleavage; 2, cleavage into four cells; 3, multicellular stage.

plication of the cells. That which I wish to call your attention to can be well demonstrated by the comparison of the first figure, in which there is a single nucleus, with the figure at this point having a number of nuclei. Both figures represent the very earliest stages of development and show the full size of the whole germ, which is about the same in the two stages. The total amount of living material has not changed essentially, but evidently there has occurred a marked increase of the nuclear substance. The nuclei have in the right-hand figure multiplied in number and their combined volume is much greater than the total volume of the single nucleus in the left-hand figure.

We can get a further notion of the nuclear increase by studying the very early development of a salamander. Here upon the screen is the egg of a salamander. It represents really but a single cell. It then divides into two cells; each of those cells has a nucleus which we can not see because these pictures are taken from the living egg, and the living egg is not transparent. Here it is dividing into four, here the upper portion of the four cells has been split off, and we have seven cells showing in the figure, and an eighth on the back. Here the number of cells has increased very much, and as you view these figures you will notice that they look very much indeed like oranges divided into segments. It seems, in fact, as if this egg, which was spherical in form, were being divided up into a certain number of segments. The process was first observed in the eggs of some of the amphibia, frogs, toads and salamanders, and it was therefore called segmentation, because it was not known at that time what the process really meant. We have then before us an ovum and a series of stages of the segmentation of the ovum, and the result of that segmentation is to produce an

ever-increasing number of cells which, in the last of the figures upon the screen, have become so numerous that we are no longer able to readily count them. Every one of these cells has its own nucleus. When the process of segmentation is complete and reaches its final limit, we then see, if we examine that stage of development, cells of the young type, such as I have described to you, in which there is a nucleus with a small amount of protoplasm about each nucleus. It seems to me, therefore—and this is a new interpretation which I present

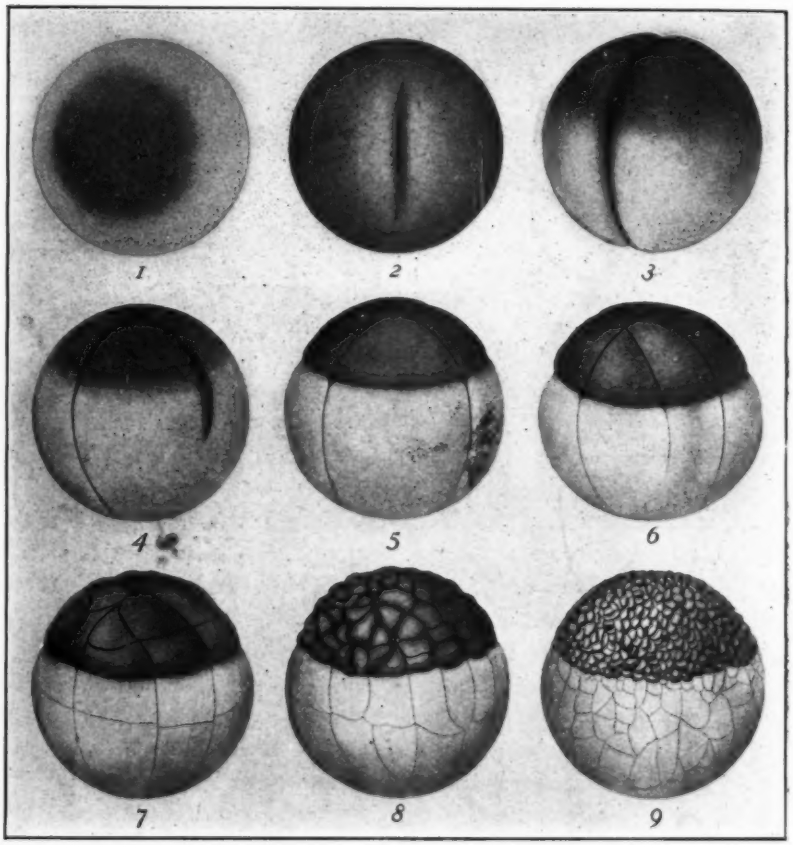


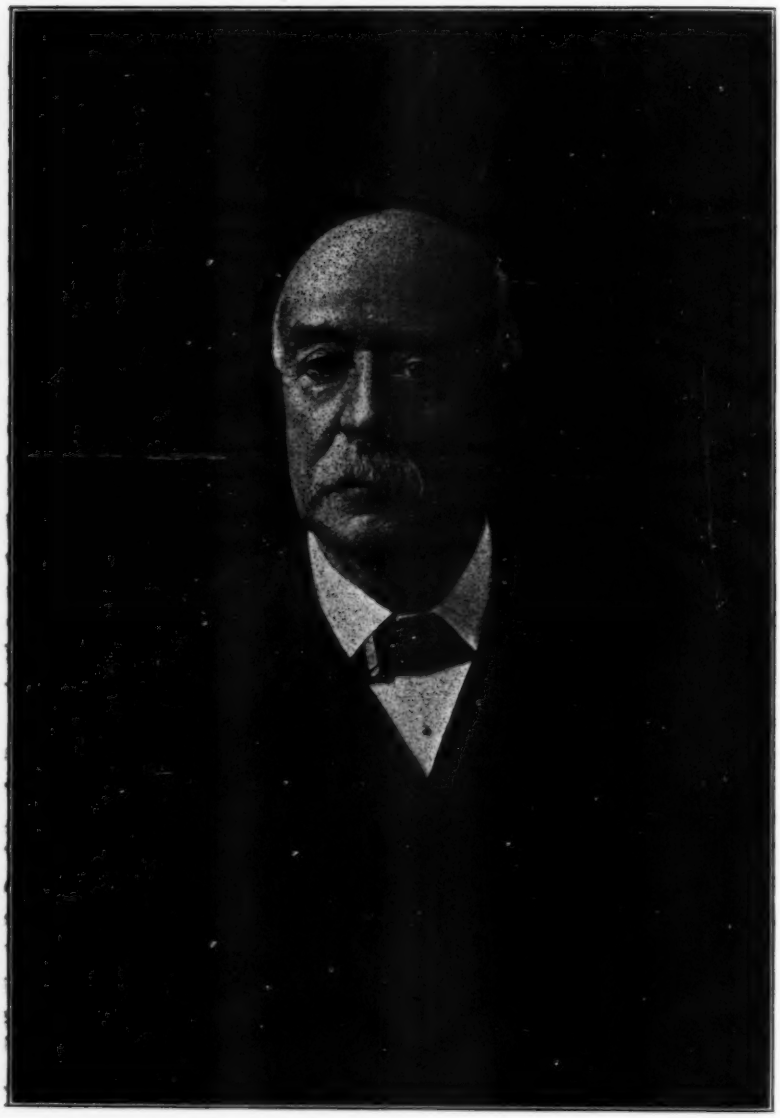
FIG. 50. *Amblystomum punctatum.* PROGRESSIVE SEGMENTATION OF THE OVUM. 1, unsegmented ovum; 9, advanced segmentation.

to you—that the process of segmentation of the ovum, with which the development of all the animals of the higher type invariably begins, is really the process of producing young cells. It is the process of rejuvenation. There is not any considerable growth of the living protoplasmic material of these eggs, and at the final stage the total volume of the egg is scarcely bigger than before; and such increased volume as has occurred has been due to the absorption of some of the surrounding water. In many animals not even this increase by the absorption

of water takes place. During the segmentation of the ovum the condition of things has been reversed so far as the proportions of nucleus and protoplasm are concerned. We have nucleus produced, so to speak, to excess. The nuclear substance is increased during this first phase of development.

Naturally, as we embryologists looked upon these things in earlier days and thought of the progress of development, we conceived of the earlier stage as younger, and of the ovum as being the youngest stage of all, a conception which in terms of time is obviously correct, but as regards the nature of the development, it seems to me clearly, is not correct. The ovum is a cell derived from the parent body, fertilized by the male element, and presenting the old state to us, the state in which there is an excessive amount of protoplasm in proportion to the nucleus; and in order to get anything which is young, a process of rejuvenation is necessary, and that rejuvenation is the first thing to be done in development. The nuclei multiply; they multiply at the expense of the protoplasm. They take food from the material which is stored up in the ovum, nourish themselves by it, grow and multiply until they become the dominant part in the structure. Then begins the other change; the protoplasm slowly proceeds to grow, and as it grows, differentiation follows, and so the cycle is completed. Whether other naturalists will be inclined to accept this conception that the process of the segmentation of the ovum is that which we must call rejuvenation or not, I can not say, for the matter has as yet been very little discussed, but you will see that it hangs as a theory well together. We have first an explanation of the process of the production of the young material, and out of that young material the fashioning of the embryo. The cycle of life has two phases, an early brief one, during which the young material is produced, then the later and prolonged one, in which the process of differentiation goes on, and that which was young, through a prolonged senescence, becomes old. I believe these are the alternating phases of life, and that as we define senescence as an increase and differentiation of the protoplasm, so we must define rejuvenation as an increase of the nuclear material. The alternation of phases is due to the alternation in the proportions of nucleus and protoplasm.

In the next lecture I shall be able to convince you, I hope, that this conception of the relation of the power of growth to the proportion of nucleus and protoplasm enables us to understand various problems of development, certain possibilities of regeneration and reconstruction of lost parts, and that it also leads us naturally forward to the consideration of the problem of death as it is now viewed by biologists, so that our next lecture will be upon the subject of regeneration and death, the natural topics to follow after to-night's discussion.



MR. ALEXANDER AGASSIZ.
President of the Seventh International Zoological Congress.

THE PROGRESS OF SCIENCE

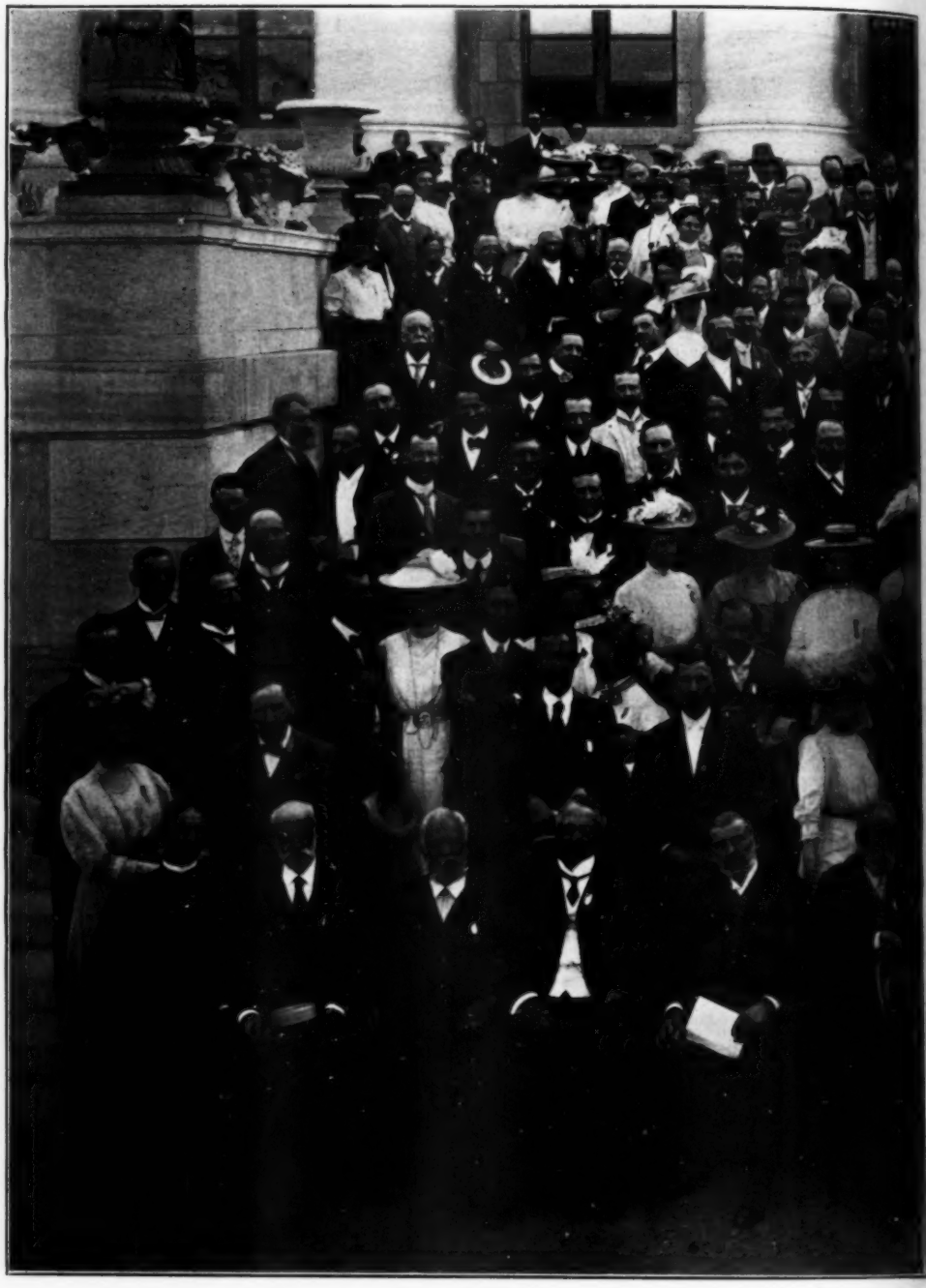
THE INTERNATIONAL ZOOLOGICAL CONGRESS

THE Seventh International Zoological Congress, held at Boston on August 19–24, was probably a greater success than its promoters had ventured to hope. Although it may have seemed inappropriate to hold it anywhere but in, or close to, Agassiz's famous museum at Cambridge, all disappointment on this score was quickly forgotten upon reaching the magnificent new buildings of the Harvard Medical School. Rarely had zoologists been so splendidly housed; and never, perhaps, had they received more open-handed hospitality from the people among whom they had chosen to meet. The attendance at the congress was very large, including distinguished workers from Japan, Russia, Austria, etc., with large delegations from Germany, France and England. No single man can sum up the achievements represented by the assembly, but counting work instead of heads, it is possible that as much as one fourth of the total zoological strength of the world was represented. The papers and addresses, as at all such gatherings, were of all degrees of interest and importance; but it is certainly true that many noteworthy contributions were offered. Perhaps the greatest enthusiasm was aroused by Bateson's address on problems connected with heredity. The whole subject of genetics, as Bateson calls it, was very much to the front, and anything in reference to it was eagerly received. Tower, of Chicago, the author of the remarkable researches on the potato-beetle and its allies, was present; and Shull's account of his experiments with the "elementary species" of shepherd's purse was welcomed, though actually botanical. It is an interesting sign of the times that a paper dealing exclusively with plants should be considered appropriate at a zoological congress; an indication that biology is again coming to be studied in a broad way, and that one can not afford to ignore either animals or plants, when dealing primarily with the one or the other.

At the general meetings, held at Jordan Hall, it was a keen pleasure to see and hear such standard bearers of the science as Hertwig, Murray and Brooks, not to speak of Alexander Agassiz, the president of the congress. At the last general meeting the report of the committee on nomenclature was unanimously adopted, and thus some matters of importance, which had long been in dispute, were at length settled, so far as they can be by such means.

Several excursions were arranged for the members of the congress. One to the Arnold Arboretum gave the foreigners an opportunity of seeing a fine series of living American trees; while the geneticologists, if one may so call them, were glad to be conducted by Professor Sargent through his plantation containing species of thorns. Another party was conducted to the place where extensive experiments are being made in rearing the parasites of the gypsy moth, and all who saw this work came back with enthusiastic accounts of it. On another day the congress was entertained at Wellesley College; while on Saturday a visit was made to Harvard University, where President Eliot and Mr. Agassiz made brief speeches explaining the history and nature of Harvard University in general and the Museum of Comparative Zoology in particular.

At the termination of the Boston



MEMBERS OF THE INTERNATIONAL ZOOLOGICAL CONGRESS

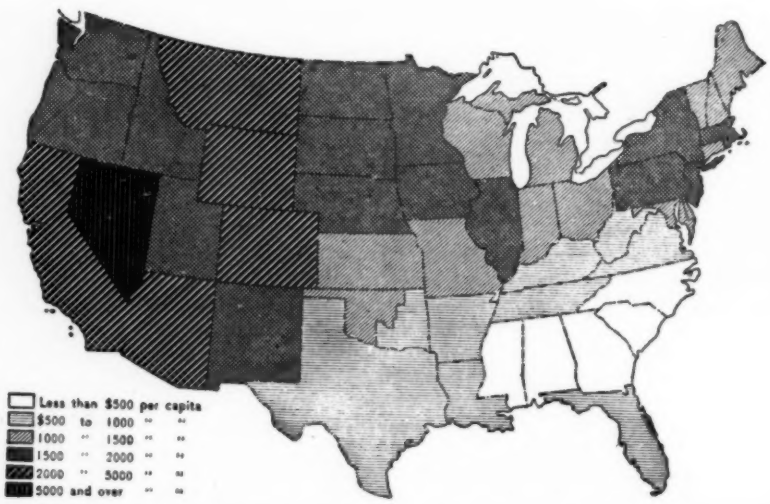
AT THE HARVARD MEDICAL SCHOOL.

week the congress went to Woods Holl, where they were shown all that the laboratories held. A pleasing feature of this visit was the reading of a letter from Dr. Dohrn, of the Naples Zoological Station, regretting his inability to be present, and the sending to him of a warm message of regard, signed by all in attendance. In the afternoon of Sunday the members embarked on the *Fishhawk*, on their way to New York, a sample dredging being made so that all might see the method employed by the Bureau of Fisheries in exploring the local waters.

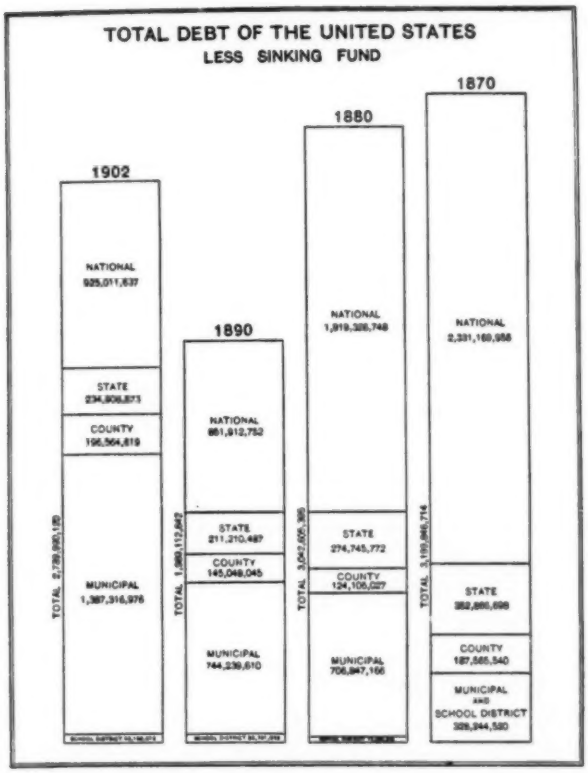
The excursion was continued in New York, Philadelphia and Washington, the members being elaborately entertained in each city, with special reference to the scientific and zoological interests. Thus in New York a day each was devoted to Columbia University, the American Museum of Natural History, the Station for Experimental Evolution of the Carnegie Institution at Cold Spring Harbor, New York, the Zoological Park and a trip up the Hudson to Garrison as guests of Professor Osborn. On Saturday there were trips to Yale and Princeton. On Monday and Tuesday in Philadelphia the members visited the Academy of Natural Sciences, the Zoological Garden, the American Philosophical Society and the University of Pennsylvania. At Washington the visitors were welcomed by Secretary Wilson and shown under the most favorable auspices the vast work being accomplished for science by the national government. A trip to Niagara Falls and the University of Toronto completed the excursion, which had been remarkably well arranged and with which the foreign delegates expressed themselves as more than pleased.

THE WEALTH OF THE UNITED STATES

THE census office has issued a report of more than 1,200 quarto pages containing a vast amount of information in regard to the wealth, debt and taxation of the country in 1904. The total wealth is placed at about 107 billion dollars, as compared with 88 billion in 1900, 65 billion in 1890 and 43 billion in 1880. The per capita wealth is now $1,318, and the annual increase not far from $40 per year. While the per capita wealth of Great Britain, France and Australia is



PER CAPITA WEALTH FOR EACH STATE AND TERRITORY, 1904.



slightly larger, the total wealth of the United States surpasses by far that of any other country. The per capita distribution, as shown on the map, will surprise some readers. It is over $5,000 in Nevada, and over $2,500 in California and Montana, whereas it is under $2,000 in New York, Pennsylvania and Massachusetts. It is greater in Iowa than in Pennsylvania or Illinois. The form of wealth is in round numbers distributed as follows: Real property and improvements, 63 billion dollars; live-stock and farm implements, 3 billion dollars; manufacturing machinery, 3 billion; gold and silver bullion, 2 billion; railways, 11 billion; street-railways, etc., 5 billion; manufactured products, etc., 18 billion.

The total national, state and municipal debt of the country in 1902 was about two billion, seven hundred and ninety million dollars, or $35.50 per capita. This is an increase of about 800 million dollars since 1890, but a decrease as compared with 1880. The accompanying chart shows the distribution of this debt, the most striking fact being the steady decrease in the debt of the national government and the increase in municipal debts. This is of course a gratifying change, the national debt being due to the cost of war, and municipal debt in the main to improvements of lasting value. The per capita national debt has decreased from $60.46 in 1870 to $11.77 in 1902. As the rate of interest has very greatly decreased, the burden of the national debt on each individual is now comparatively slight. It would, however, seem to be only the prudence that is expected from each citizen for the whole nation to pay its debt without undue delay. It is a question whether it would not be wiser for municipalities

to invest their savings in improvements rather than to contract debts, but this is an open question, as it is reasonable to expect future years, and even future generations, to pay for advantages that may be bequeathed to them. The report contains a very elaborate discussion of the taxation and revenue systems of the United States and of the several states. In 1902, the total expenditures of the national government were about 617 million dollars; of the states and territories, about 85 million; of the counties, 197 million; of the cities 551 million, and of other minor civil divisions 222 million. The receipts from revenues almost exactly balance the expenditures.

SCIENTIFIC ITEMS

We record with regret the death of Dr. William Thomson, an eminent ophthalmologist of Philadelphia, and of Dr. Gaylord P. Clark, dean of the college of Medicine and professor of physiology at Syracuse University.

Professor Ludwig von Graff will be president of the eighth Zoological Congress, which is to be held at Graz three years hence.—Professor J. J. Stevenson, of New York University, and Professor W. M. Davis, of Harvard University, were delegates from the Geological Society of America to the centennial celebration of the foundation of the Geological Society of London, which took place at the end of September.

Dr. E. Ray Lankester will retire from the directorship of the Natural History Museum, London, in October. It is understood that the inadequate pension originally proposed by the trustees has been about doubled. The trustees have decided not to appoint a new director, though it is possible that this plan may be changed.—At the Meudon Experiment Station, which is affiliated with the Collège de France, M. Daniel Berthelot has been appointed director of the laboratory for plant physics, and M. Muntz, director of the laboratory for plant chemistry.—By an act of the last legislature, the professor of geology at the State University of Colorado became also, by virtue of his office, the state geologist. $5,000 is appropriated annually for this service.

Yale University has received a bequest calling to mind that of Smithson for the establishment of the Smithsonian Institution. Archibald Henry Blount, an Englishman, who is not known to have been in America or to have had any conection with Yale University, has made that institution his residuary legatee, to which it will profit to the extent of about $400,000. Yale University has also received $150,000 for a lecture hall for the Sheffield Scientific School. This is a gift of Mrs. James B. Oliver, in memory of her son, a former student of the school, who was recently killed in an automobile accident.